

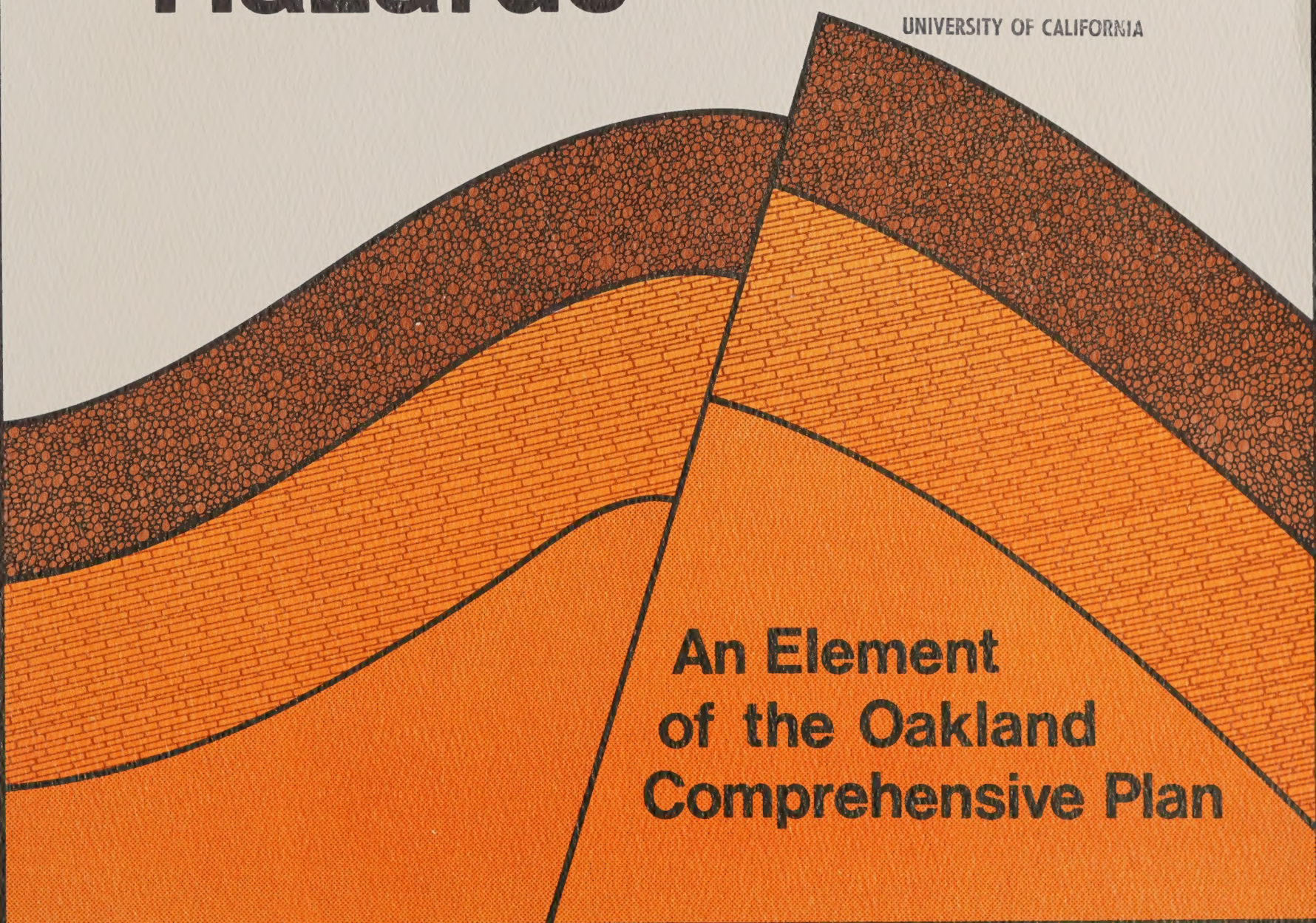
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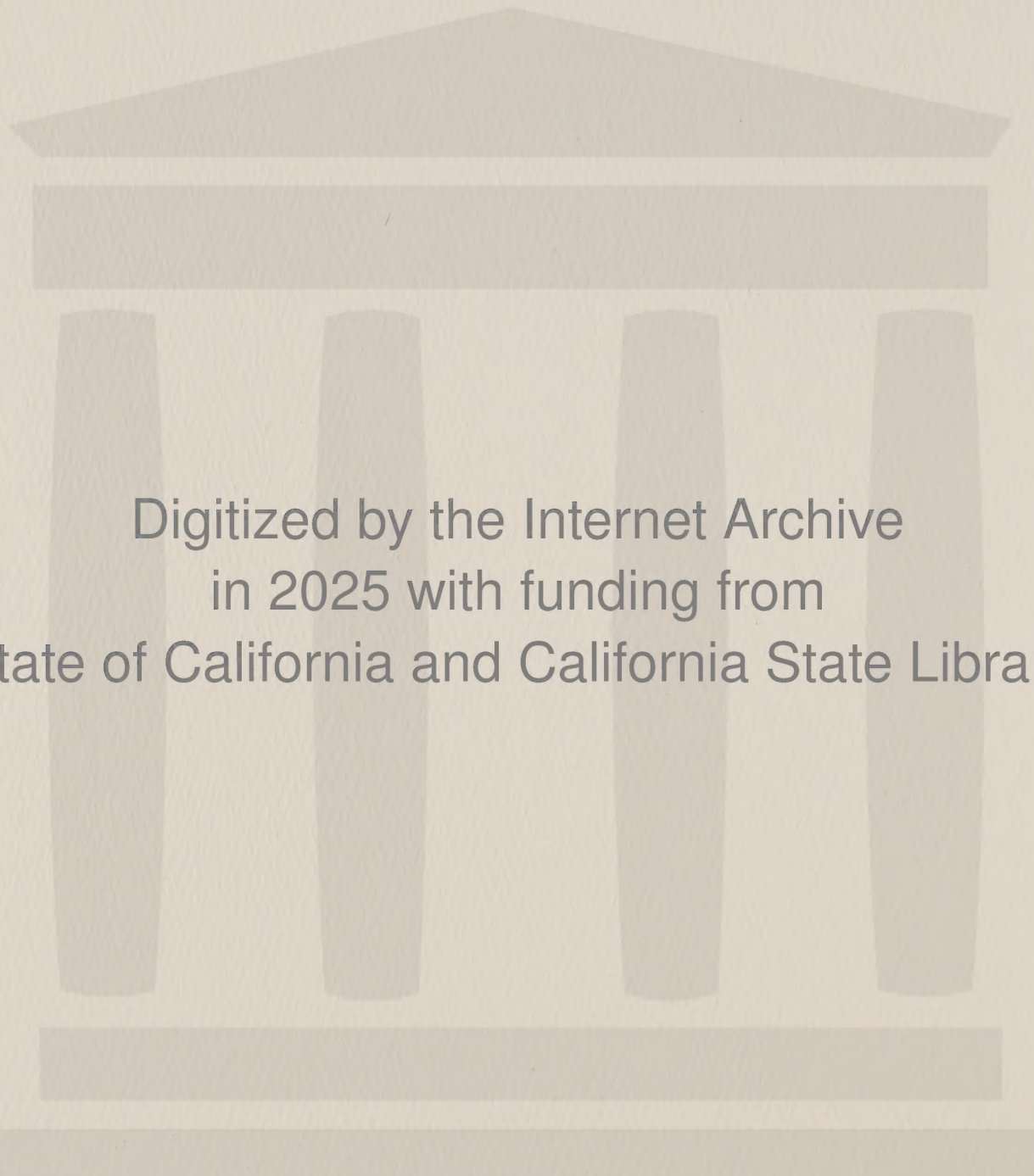
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An Element
of the Oakland
Comprehensive Plan



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Environmental Hazards

An Element
of the Oakland
Comprehensive Plan

City of Oakland
September, 1974

city planning Oakland
Emergency relief Earthquakes
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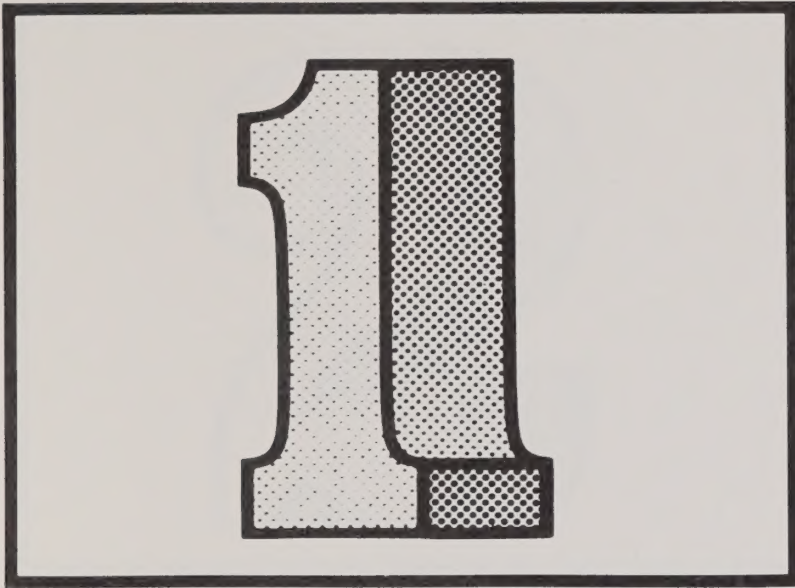
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Introduction

Earthquakes, fires, floods and other natural disasters have plagued civilization throughout history. They continue to do so today despite the capacity of our society to deal with them. This report directs its attention to steps that might be taken in Oakland to cope with the possibility of such natural disasters.

First, it identifies and analyses the seismic, geologic, fire and flood hazards that exist in Oakland. It then sets forth goals and policies for dealing with these hazards. Finally, it suggests programs to alleviate hazardous situations in the City.

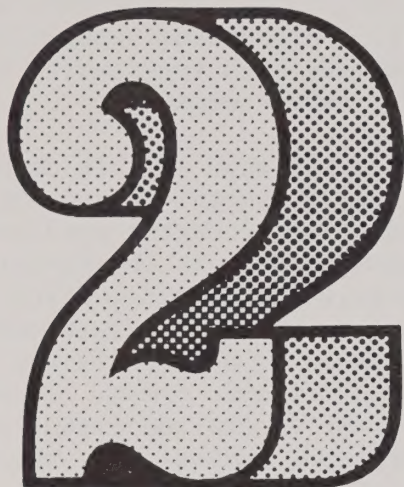
The concerns expressed in this report are statewide. Every city in California has been mandated to adopt policies and programs to deal with natural disasters. State requirements specifically call for a Seismic Safety Element and a Safety Element to be added to the General Plans of cities. The Seismic Element generally is to deal with seismic hazards which can be identified in a community in addition to the development of procedures to alleviate possible losses due to earth movements. The Safety Element is concerned

with fire, floods, and other geologic hazards including the development of a disaster plan in the event of such an occurrence

Since the concerns of these two elements are so closely interrelated, they have been combined here into one study. This report therefore constitutes Oakland's Seismic Safety and Safety Elements.

In Oakland, the General Plan required by State law is called the Oakland Comprehensive Plan. The Comprehensive Plan consists of the Oakland Policy Plan and any other element (report, plan, action program) the City Council declares to be part of the Plan.

This report, as adopted, has become a part of the Oakland Comprehensive Plan. Additionally, the policies which are adopted as part of this Element have been included in the Oakland Policy Plan.



Background

Seismic Activity

The movement of the earth's crust is part of the general geologic evolutionary process which is continually taking place. Existing geologic theory holds that the movement of the plates which compose the earth's crust continually causes strains to build at the plate boundaries. These strains accumulate until the plates can no longer sustain the strain. Then there is an energy release.

The primary forms of this release are ground shaking, rupturing, and tectonic creep. Ground shaking is the result of wave movement through the rock materials of the earth's outer crust. Depending on the geologic and soil conditions of a given area, ground shaking effects can either be amplified or dampened. Rupturing of the ground is associated with more intense earthquakes. This form of seismic expression occurs along the faults of the earth's crust. These faults are the boundaries between the crustal plates. The ability to predict where such actions will occur is impossible, but records show

these actions usually occur in areas of previous ground rupture. The last and least noticeable seismic expression is tectonic creep. This is a very slight continuous movement along a fault, usually in a lateral direction. Creep movement is most often only in fractions of inches per year. Ground shaking and rupturing, potentially the most violent expressions of seismic activity, allow the release of stresses such that a crustal plate can shift to a position of lower stresses. Once these abrupt movements have occurred, it is believed that the process begins again with the gradual build up of strain.

This continual accumulation and release of strain is common along the margins of the earth's crustal plates. These areas are the most prone to seismic activity and are generally referred to as "earthquake belts." California is located in the Circum-Pacific Seismic Belt which extends, in part, the length of the western portion of the Western Hemisphere.

FAULT TRACES

For planning and land utilization purposes there are basically two types of faults which are of concern--active (or potentially active) and inactive faults. An active fault is one which has experienced movement in recent geologic time and which may move again in the relatively near future. Inactive faults show no evidence of movement in recent geologic time and present no evidence of a potential to move in the relatively near future.

Faults, which separate two plates of the earth's crust, are not easily identifiable, especially at the earth's surface in developed areas. Geologists can however, through the analysis of existing land formations, instrumentation, and various tests, identify general fault locations. An earthquake fault may be a single continuous line, but more likely is a system of splinter faults and breaks which together constitute a fault zone.

SEISMICITY OF OAKLAND AND THE BAY AREA

Earthquakes occur frequently throughout the San Francisco-Oakland Metropolitan Area. The Bay

Area has three distinct zones of earthquake activity running through it. These zones coincide with the four known fault zones in the area. These are, from southwest to northeast, the San Andreas, the Sargent, the Hayward and the Calaveras faults. (See Map 1; Sargent not shown.)

The San Andreas, the Calaveras, and the Hayward faults each have generated major earthquakes with measurable amounts of surface displacement in historic time. Locally there is also evidence of tectonic creep along each of these faults.

The earliest earthquake known historically in the Bay Area occurred in June 1836 on the Hayward fault. The intensity rating of this shock has been set at between X and XI on the Modified Mercalli (MM) Scale (see Glossary for scale definition). The next severe shock occurred in late June 1838 on the San Andreas fault near Palo Alto. This was rated X on the MM Scale. The next shock was in 1865 along the San Andreas with an intensity of at least VII(MM). Three years later the most severe of the pre-1906 earthquakes took place along the Hayward fault. The shock, centered on the town of Hayward, resulted in loss of life and extensive structural damage especially on the filled areas and the mudflats throughout the Bay Area.

The most significant earthquake in the Bay Area's history in terms of lives lost and property damage occurred in April, 1906. Surface faulting nearly 270 miles in length from San Juan Bautista on the south to Point Arena on the north was observed. Seven hundred lives were lost and the property damage was estimated at four hundred million dollars. In the past few years the largest earthquakes were recorded in 1969 in the Santa Rosa area.

Although these earthquakes were the most significant in the area, there have also been numerous smaller shocks, detected only by sensitive seismographs. Additionally, there is a continuing problem of gradual creep or slippage along some parts of the Bay Area's faults. There seems to be a close correlation between the most active

linear seismic belts and fault segments that are undergoing creep. This is the case along the Hayward fault. This gradual creep is sufficient to damage man-made structures which cross seismically active fault segments.

Some fault segments that exhibit abundant seismic activity and measurable creep are those that have ruptured abruptly during previous large shocks. A good example is the Hayward fault in 1868. Large earthquakes and surface movement seem to also occur on those fault segments where part of the strain is being relieved by small earthquakes and tectonic creep. Therefore the presence of minor shocks and creep are not necessarily safeguards against more severe earthquakes.

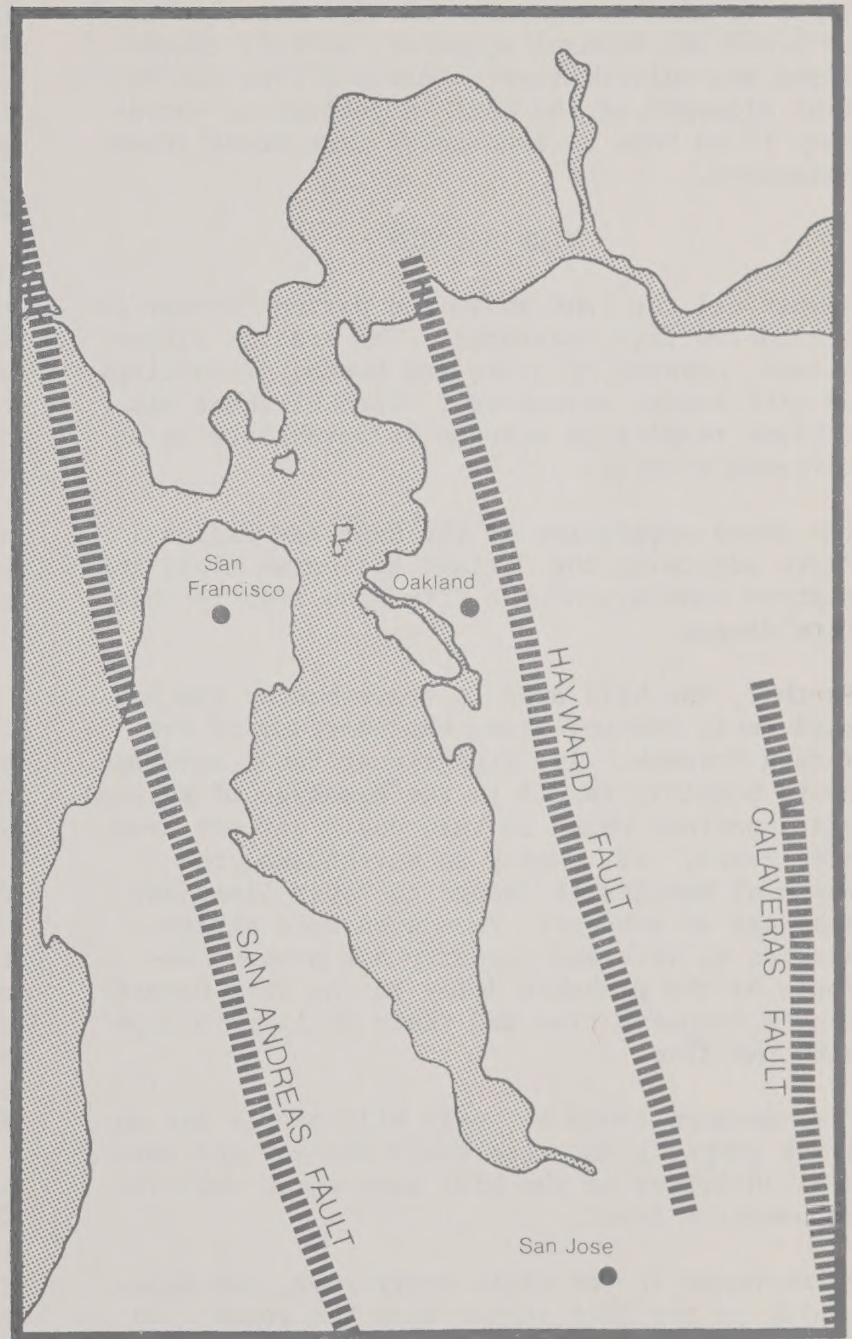
EARTHQUAKE PREDICTION

There are basically three aspects of potential earthquakes which must be known to make any prediction significant: 1) location, 2) magnitude, and 3) time. Earthquakes will occur again in locations where they have previously occurred. Therefore it can be predicted that the San Andreas and Hayward faults will experience earthquakes in the future. However, the exact location of these cannot be pinpointed.

Earthquakes along active faults more than likely will be of the same magnitude as those experienced in the past. The ability to accurately predict the magnitude of future shocks is not possible at this time. It can be said however, that large earthquakes will most likely occur where they have previously occurred.

The third element of prediction--time--is even harder to draw conclusions about. California, according to knowledgeable earth scientists, will continue to periodically experience severe shocks. The year, month, day and hour of an earthquake however is not within the realm of scientific predictability at this time.

While the location, magnitude, and time of an earthquake cannot be predicted at the present,



MAP 1

Earthquake Faults of the Bay Area

there is continuing research into earthquakes by State and Federal agencies, as well as colleges and universities. Research into the various elements of the earth's geology is necessary if we hope to eventually understand these phenomena.

FIRE HAZARDS

Almost all the land above the Warren Freeway is considered fire hazardous. The area is either wooded, covered by grass and brush, or developed with wooden structures. Each of these situations results in extreme vulnerability in an outbreak of fire.

The dense vegetation of the East Bay Regional Parks adjoining the Oakland hill area along the eastern boundary of the City also adds to this fire danger.

Further, the hill area is traversed by the Hayward fault running along the corridor of the Warren Freeway. Any significant fault movement could possibly result in the breakage of natural gas pipelines which in turn could set off area-wide fires. If, during an earthquake, the movement results in damage to water lines and blockage of roadways, then even more severe hazards to life and property are present because of the probable delay in the Fire Department's response time and their ability to cope with the fire.

Fire dangers could not only kill people and destroy property but also could destroy the natural qualities of the hill area which make it a community asset.

Fires occur in the hills every year, and especially in the late summer when the vegetation is dry. The City's Fire Department is usually able to control the fires to avoid major losses. However, critical fires still occur and serious losses are at times unavoidable.

An extensive fire, centering on Marlborough Terrace and Norfolk Road in the North Oakland

hill area, occurred in 1970. Flames broke out in the dry brush and grasslands surrounding the residential neighborhood. In 80 degree temperature, the dry but not especially strong winds propelled the fire into the tree tops, and the fire spread quickly, leaping from place to place. The fire covered 200 acres and destroyed 37 homes.

During the second week of December, 1972, temperatures fell to the mid-20's and resulted in a freezing death for approximately two million eucalyptus trees in the hill areas. Recognizing that the dead trees could become a powerful source of fuel during a fire, the City and the State designated this a disaster area and developed detailed plans for responding to the potential disaster. Fortunately the disaster has not occurred, but the potential for such a disaster is still real.

FLOODING

The City of Oakland is not considered a flood prone community. Natural and man-made storm drainage facilities are capable of accommodating all but the most severe storm conditions.

The City's storm drainage is provided primarily by a series of creeks with headwaters extending to the crest of the Oakland hills along the eastern edge of the City. The creeks generally follow steep natural channels until they reach developed areas, where, except in the cases of the larger creeks, they have been placed underground in culverts to their points of discharge in the Bay.

According to recent engineering studies, the City's drainage systems are adequate to carry the ten-year storm runoff, and in most cases the twenty-five year storm runoff. However, with larger storms, general flooding would occur. Much of this flooding would occur as sheet flow in the streets. But as the storm magnitude increases, sufficient volumes of water would rise above the creek banks in the upper reaches and cause more significant flooding. Street water would tend to flow to the lower, flatter areas of the City. Ponding would occur in those areas where the rail-

roads and major roadways paralleling the Bay have been built at a slightly higher elevation than the adjacent areas.

Oakland experienced its worst flooding conditions during the storm of October 12 and 13, 1962, with the subsequent runoff causing extensive damage to the Eastbay area. As a result of this storm, residents requested the City Council to obtain flood control assistance from the Alameda County Flood Control and Water Conservation District. On October 16, 1962, the City Council adopted a resolution requesting a special assessment district for the construction of flood control and storm drainage facilities where needed throughout Oakland. On January 2, 1963, the Alameda County Board of Supervisors adopted a resolution forming Flood Control Zone No. 12 to include all of the area within the cities of Oakland and Emeryville.

The Flood Control District's work is generally on schedule, and the completion of all major improvements is anticipated by 1978. The District also assumes responsibility for the maintenance of its facilities in cooperation with the City of Oakland Street Maintenance Division, which assumes the responsibility for keeping the street drains and drainage inlets free of debris.

SOURCES OF DATA

The data included in this study for the most part has been developed by other agencies whose primary functions include research in areas concerned with the earth's geology, seismic activities, flood and fire hazards.

In many instances, data has been generalized to apply to the Oakland situation. Seismic data for the Hayward fault zone developed over a period of years by a number of agencies has been drawn upon extensively.

The recent increased concern with potential earthquake hazards will probably generate more efforts in the areas of data collection and analysis. As Federal and State agencies devel-

op more precise and usable data in these areas it may become necessary to revise some of the information contained in this report.



Identifying Environmental Hazards

Geologic Hazards

What happens as a result of an earthquake is primarily determined by the geologic structures of an area. Additionally, the identification of potential landslide areas and other geologic hazards can be determined through an analysis of the existing geology.

The geologic analysis presented here on a city-wide basis is necessarily generalized. The primary data source for this analysis was U. S. Geological Survey maps and publications. The maps attempt to outline general areas of Oakland which contain specific geologic features, or which could be subject to certain types of geologic hazards. The geologic information in this study alone cannot be utilized to determine findings for any specific site. Rather, if information is needed for a specific site, soils studies and geo-

logic reports for that particular site would be required. In the future, new geologic data for Oakland may be developed, and with increased geotechnic knowledge, the findings of this chapter may be adjusted to maintain their validity.

GENERALIZED GEOLOGY

Oakland can be generally divided into six geologic areas as shown on Map 2:

- A. Bay Marshlands, Mudflats and Fill Areas - the composition of this material varies from place to place. Some portions of fill may contain concrete, bricks and other miscellaneous refuse.
- B. San Antonio Formation (Upper Member) - the materials contained in this formation are clay, silt, sand and gravel. The maximum thickness of the clay layers is unknown. The overburden is largely older alluvial fan deposits which may be up to several hundred feet thick in certain places. It is generally suitable foundation material for light structures where slopes are not steep.
- C. Undivided Quaternary Deposits - this consists of predominantly the Temescal Formation, possible San Antonio Formation, gravel, sand, clay and artificial fill. The overburden varies considerably in compaction as well as depth. Depending on composition it has generally good stability.
- D. San Antonio Formation (Lower Member) - this consists of weathered dense gravel with silty clay matrix. The material above bedrock should be fairly shallow. It is generally stable.
- Leona Rhyolite - this is composed of rhyolite, some pyrite and glass. These are shallow soil deposits over the bedrock which are mostly covered by younger alluvial fan deposits. Slope stability and foundation conditions are good.
- F. Undivided Upper Cretaceous Rocks - this includes the Redwood Canyon Formation, Shepherd

FIGURE 1
GEOLOGIC TIME SCALE

Geologic Age			Years before present (estimated)
Era	Period	Epoch	
CENOZOIC	QUATERNARY	"Historic"	200
		HOLOCENE	11,000
		PLEISTOCENE	
	TERTIARY	PLIOCENE	2,000,000 3,000,000
		pre-PLIOCENE	7,000,000 10,000,000
			pre-CENOZOIC time
Beginning of geologic time			4,600,000,000

Faults defined as active by Policies & Criteria of the State Mining & Geology Board.

Creek Formation, Oakland Conglomerate and Joaquin Miller Formation (various areas of sandstone, shale and minor conglomerate). Many of the areas have little or no overburden. Slope stability and foundation conditions are good to poor. It may be subject to minor sloughing and major sliding.

The greatest portion of Oakland, including much of North Oakland, East Oakland, West Oakland, and the central district is underlain with quaternary deposits, including some artificial fill. The stability of this material is generally good.

Major portions of the Oakland Hills consist of undivided upper cretaceous rocks. Stability in this area generally depends on the particular formation in a specific area and may vary from good to poor.

The areas adjacent to the Oakland Airport, the Oakland Army Base, the Naval Supply Center, and Lake Merritt are all composed of filled land, marshland, or mudflats. Properly engineered fill is generally suitable for use as foundation for lighter structures. Depending on exact composition, fill overlying bay mud is susceptible to movement under earthquake stress.

FAULT DISPLACEMENT

Fault displacement occurs when the earth on one side of a fault moves in relationship to the earth on the other side. The earth's crust is literally covered with faults most of which are extinct or have been dormant for long periods. As has been stated in the previous chapter, the most essential aspect for planning purposes is the determination if a fault is at all active.

The Hayward fault which is of prime concern to Oakland is known to be active as evidenced by historic records and the recent monitoring of tectonic creep along certain fault traces within Oakland. For the purposes of this study an active or potentially active fault is being defined as one which has been active within the Holocene Epoch (last 11,000 years). This definition is

consistent with that set forth by the California State Mining and Geology Board. A classification of geologic time is presented in Figure 1.

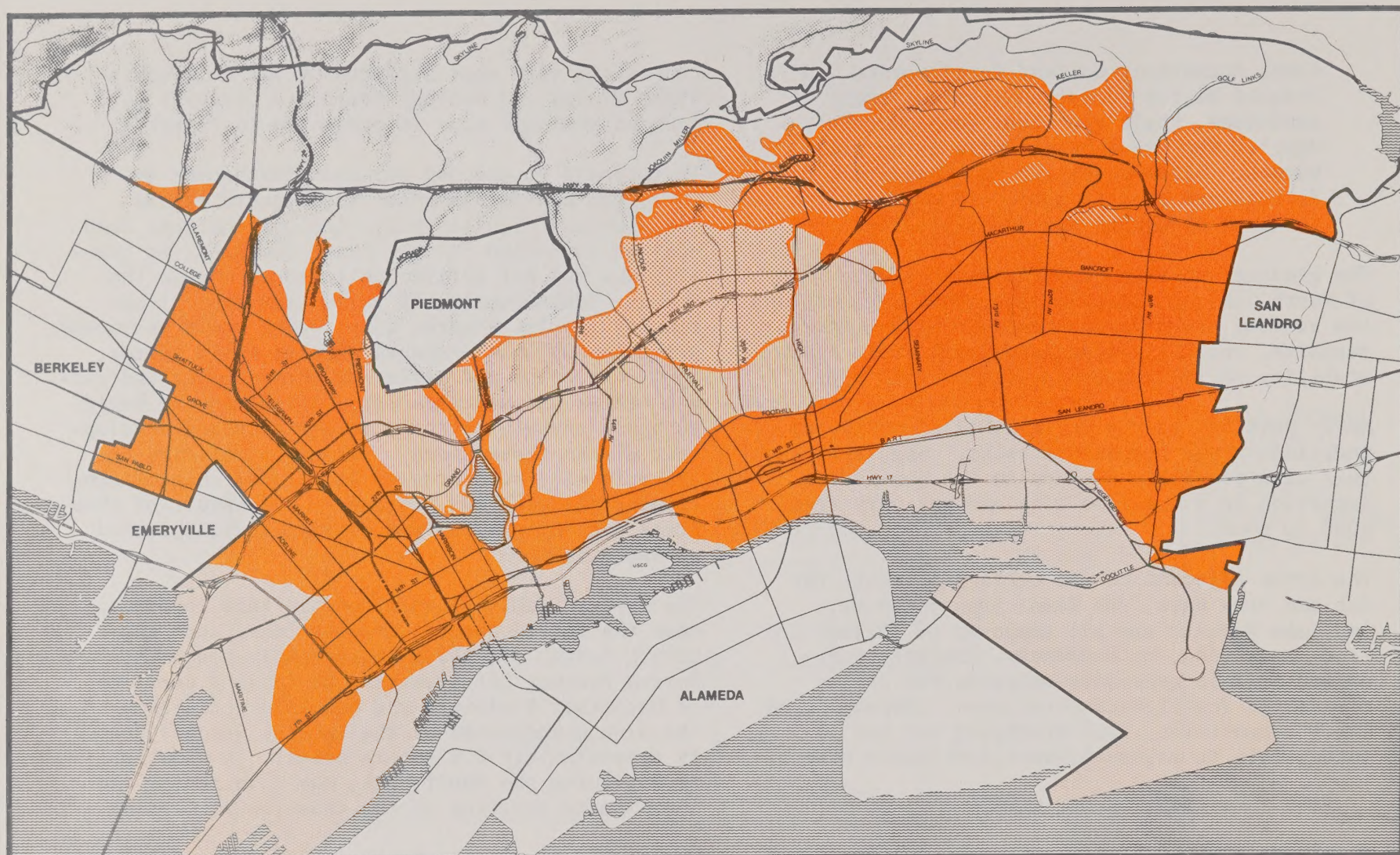
In response to the San Fernando Earthquake in 1971, the California State Legislature passed legislation (Alquist-Priolo Geologic Hazards Zone Act) which called for the State Geologist to identify and map all active fault traces within the State. Additionally, it called for the delineation of special studies zones which would encompass all potentially or recently active fault traces. Upon completion and review of this mapping individual cities and counties were called upon to begin to apply certain criteria to all proposed development within these zones. The exact policies and criteria will be discussed in a later chapter concerning policies and programs. The result of this State mapping program for Oakland is illustrated on Map 3.

The Hayward fault (a term used in this report to mean the entire Special Studies Zone) runs the entire length of Oakland principally along the Warren Freeway but branching to include portions of MacArthur Boulevard and Mountain Boulevard. The area encompassed by the Special Studies Zone is approximately 6.5 square miles. In addition to outlining the fault zone, Map 3 indicates the approximate location of the known fault traces.

The occurrence of earthquakes throughout California has been discussed earlier. Figure 2 and Map 4 document the most prominent earthquakes in the State. As evidenced by this data there haven't been any significant shocks along the Hayward fault for a great number of years. The active nature of the Hayward fault has however been well documented by monitoring devices used by the City of Oakland to measure tectonic creep.

Experts feel that this creep is not releasing any great amount of energy and earthquakes can be expected along this fault in the future.

In the event of an earthquake along this fault, movement will probably be "right lateral movement." That is, the plate opposite the one the observer



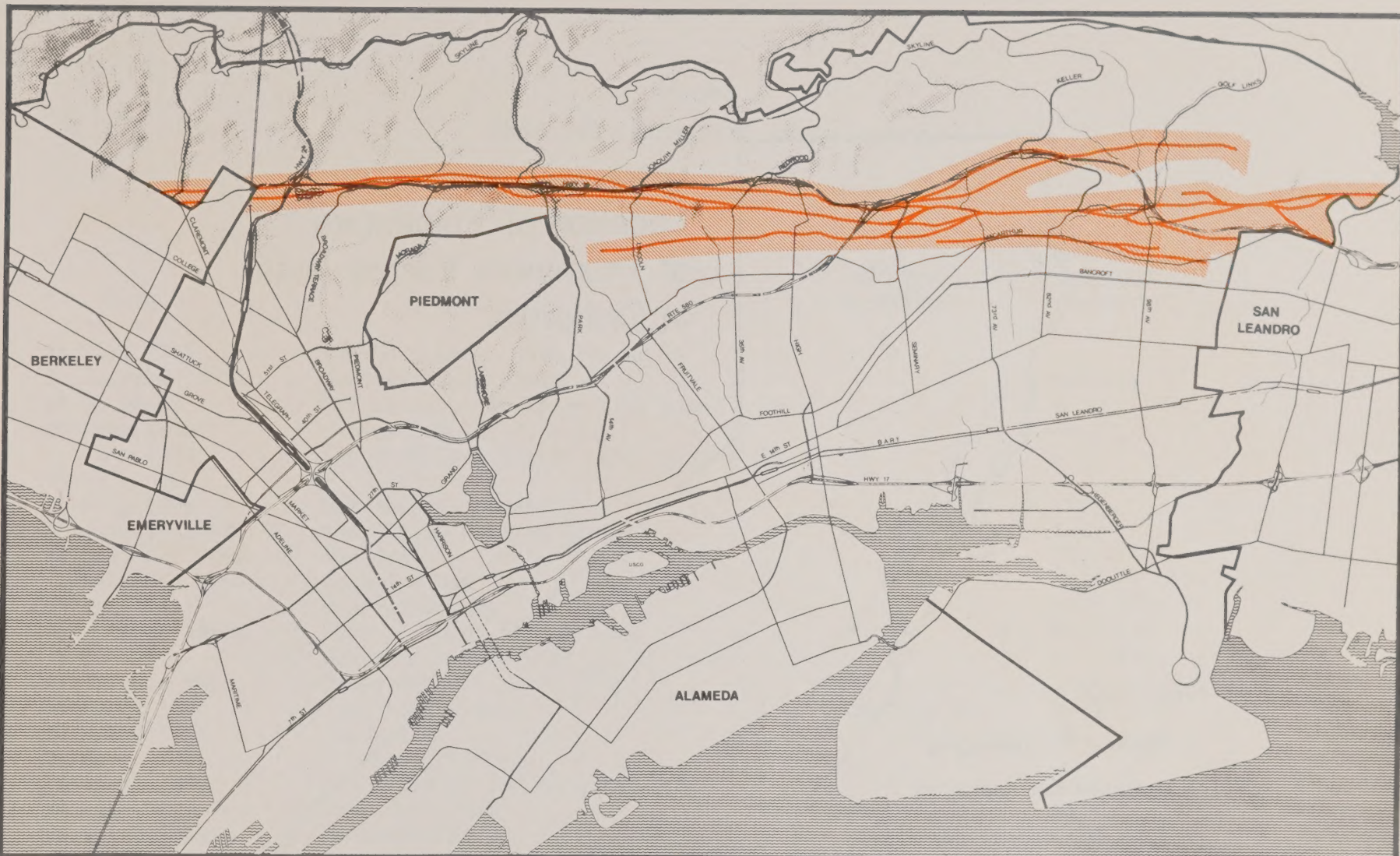
Geologic Areas

- A
- B
- C
- D
- E
- F

MAP 2 Generalized Geology



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MAP 3
**State of California
 Special Studies Zone
 Oakland**



MAP 4

Location of Epicenters
of Prominent Earthquakes
in California

MAGNITUDE

- Below 7 but damaging
- Unknown but damaging
- 7 to 7.9
- ⊙ 8 or over

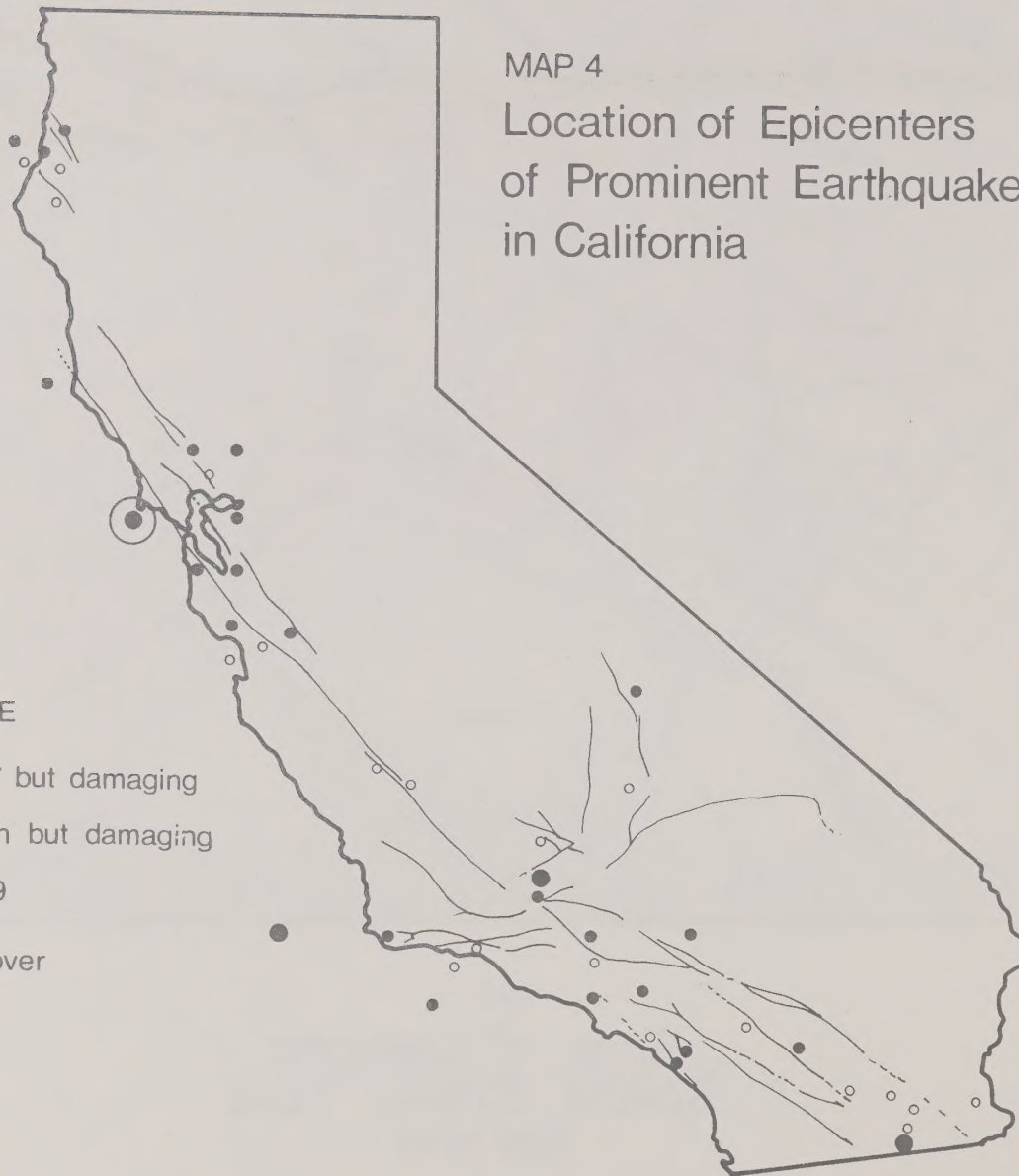


FIGURE 2
 PROMINENT EARTHQUAKES IN CALIFORNIA

DATE	REGION	RICHTER MAGNITUDE	MODIFIED MERCALLI INTENSITY
28 July 1769	Orange County, near Irvine	*	
8 December 1812	Southern California		VIII-IX
21 December	Off coast of Southern California		X
10 June 1836	Hayward fault, Berkeley		IX-X
June 1838	San Francisco region, San Andreas fault		X
10 or			
11 July 1855	Los Angeles County		VIII
9 January 1857	Fort Tejon-Carrizo Plain	Possibly 8	X-XI
26 November 1858	San Jose		VIII
November 1860	Humboldt Bay		VIII
3 July 1861	Near Livermore		VIII
1 October 1865	Fort Humboldt-Eureka area		VIII-IX
8 October	Santa Cruz Mountains		VIII-IX
21 October 1868	Hayward		IX-X
26 March 1872	Near Lone Pine	Possibly 8+	X-XI
19 April 1892	Vacaville		IX
21 April	Winters		IX
4 April 1893	Northwest of Los Angeles		VIII-IX
20 June 1897	Near Hollister		VIII
14 April 1898	Mendocino area		VIII-IX
22 July 1899	San Bernardino County		VIII
25 December	San Jacinto-Hemet area		IX
27 and			
31 July 1902	Santa Barbara County		VIII
18 April 1906	San Francisco region	8.3	XI
28 April	Brawley, Imperial Valley	6-6.9	VIII
28 October 1909	Humboldt County	6+	VIII
11 January 1915	Los Alamos		VIII
22 June	El Centro-Calexico-Mexicali area	6.25	VIII

*The Richter magnitude scale was not published until 1935. If values appear in this column for earthquakes which occurred prior to that date, the magnitudes were determined as follows: (1) if given to the nearest tenth, the records of older instruments were correlated with records of instruments now in use; (2) otherwise, historical records of intensity were used to estimate magnitude.

FIGURE 2 (Continued)

DATE	REGION	RICHTER MAGNITUDE	MODIFIED MERCALLI INTENSITY
21 April 1918	San Jacinto-Hemet area	6.8	IX
21 June 1920	Inglewood		VIII
10 March 1922	Cholame Valley	6.5	IX
29 June 1925	Santa Barbara area	6.3	VIII-IX
22 October 1926	Monterey Bay	6-6.9	VIII
20 August 1927	Humboldt Bay		VIII
4 November	West of Point Arguello	7.5	IX-X
25 February 1930	Westmorland	5.0	VIII
1 March	Brawley	4.5	VIII
6 June 1932	Humboldt County	6.4	VIII
10 March 1933	Near Long Beach	6.3	IX
7 June 1934	Parkfield	6.0	VIII
18 May 1940	Imperial Valley	7.1	X
30 June 1941	Santa Barbara-Carpinteria area	5.9	VIII
15 March 1946	North of Walker Pass	6.25	VIII
29 July 1950	Imperial Valley	5.5	VIII
21 July 1952	Arvin-Tehachapi	7.7	XI
22 August	Bakersfield	5.8	VIII
25 April 1954	East of Watsonville	5.25	VIII
21 December	Eureka	6.6	VII
12 September 1966	Truckee	6.6	VIII
8 April 1968	Northeast San Diego County	6.5	VII
1 October 1969	Santa Rosa	5.7	VII-VIII
9 February 1971	San Fernando	6.5	VIII-XI

is on appears to be moving horizontally to the right. Vertical movement along the Hayward fault (where the crustal plates slip up or down on each other) has not been documented to date. This of course does not discount the possibility of such movement in future earthquakes. Potential movement in the form of rapid displacement or tectonic creep along the fault can be destructive to structures which cross fault traces.

GROUND SHAKING

The major damage to structures and the most readily apparent sensation felt by people during an earthquake is caused by ground shaking. This phenomena is caused by the release of energy in the form of a surface wave which moves the material of the earth's outer crust. The movement created by such seismic waves is not constant, rather its direction and velocity are directly correlated to the composition and configuration of the earth's crustal material.

Structural damage caused by past earthquakes has suggested to geologists and engineers that the most severe damage to structures results where tall structures are built over thick, soft, water-saturated sediments. As seismic waves pass from rock to less dense materials, such as alluvium or water saturated rocks, they are reduced in velocity but generally increased in amplitude. As a result, shaking is accentuated at the surface and lasts for a longer period of time. Generally, the least damage to structures seems to occur when they are constructed on very firm bedrock. In fact, because of the nature of seismic wave movement through the earth, a structure built next to a fault on solid ground may withstand ground shaking better than a structure located on loosely compacted water saturated material many miles away.

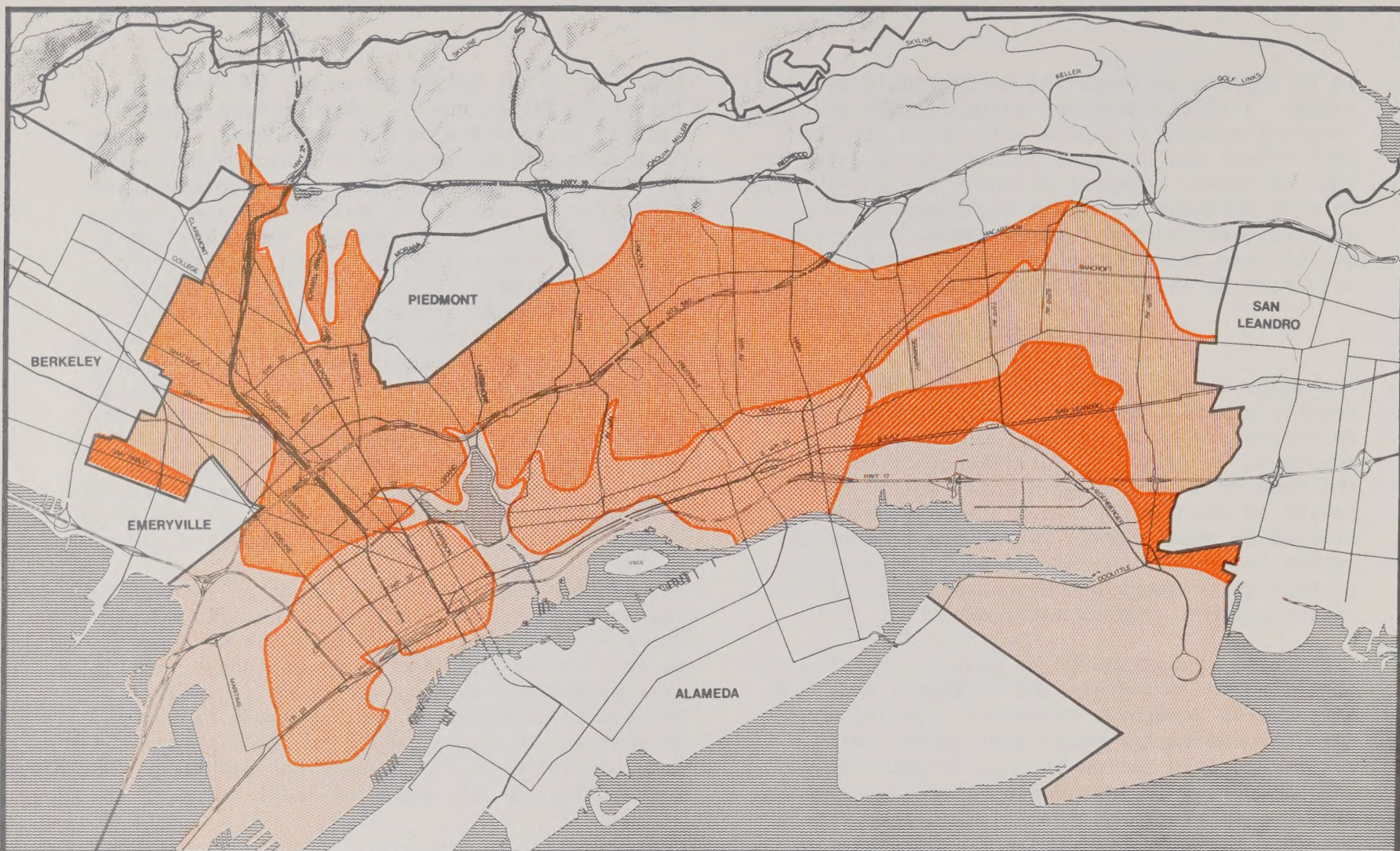
The structural integrity of buildings before an earthquake and whether the natural vibration period of the structure is coincident to that of the ground are both factors that complicate these general concepts. The predominant vibration period of a building can be related in a very gen-

eral way to its height or number of stories. Taller buildings have a longer predominant vibration period (two or more seconds). They are therefore subject to greater damage when they are located in ground with a longer predominant vibration period (thick, water-saturated sediments). When the building and the ground approach the same vibration period, damage from shaking is more likely to take place. Therefore, one- or two-story buildings with short predominant vibration periods may, in some cases, experience more damage if they are located on firmer ground. This is, of course, a very simple picture of a rather complicated phenomenon. There are additional factors which would tend to distort any generalizations on this subject. These include the magnitude, distance, frequency, and duration of a particular shock, all of which will influence the predominant vibration period.

As has been discussed, the extent of ground shaking is partially determined by the effects of the earthquake on the various types of bedrock as well as the alluvium or consolidated material overlying this bedrock. In order to generalize the ground response of various areas in Oakland, an analysis of "soil zones" in the City and their possible responses to shaking was prepared. Map 5 indicates the six outlined "soil zones."

Zone I

Zone I consists of fill material over bay mud or former marshland. Earthquake experts have generally expressed concern over the hazards associated with existing and future bay fills. Structurally poor ground (such as San Francisco Bay muds and the deep alluvial soils near San Jose and in Santa Rosa) has been associated with intensified earthquake damage. Much of the criticism directed against the development of and construction on San Francisco Bay fills is based on their past performance in large earthquakes. The 1865, 1868, and 1906 shocks have been described in varying but adequate detail. San Francisco, being the only city having significant portions of its land area on man-made fills at the time of these earthquakes, was the location



Soil Zones

- I
- II
- III
- IV
- V
- VI

MAP 5 Potential Ground Response



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of most of the property damage related to such fills. In Santa Rosa, the 1906 earthquake also caused extensive damage to buildings located on the deep, naturally deposited alluvial soils. Furthermore, some fills have performed poorly during earthquakes elsewhere throughout the world.

The hazards that exist in Zone I are two types--those related to bay mud and those related to the fill placed thereon. Hazards relating to bay mud include ground cracking, ground lurching, and differential settlement. Hazards that relate to artificial fill include differential settlement and liquefaction.

Differential settlement is a condition which may arise from either situation and is the result of poorly compacted non-uniform fill. Bay mud itself, under natural conditions, is not compacted naturally to a great degree and artificial fill may not be uniform or fully compacted. This may cause portions of structures placed on them to settle at different rates thereby causing extensive damage.

Ground cracking usually occurs as a result of differential settlement. Ground lurching is one possible result of seismic wave. This effect causes undulating waves in soft, saturated ground which may or may not remain after the shock. These waves would, of course, affect any structure built on that material, though damage could be minimized by using the proper foundations.

Liquefaction is also a possible hazard. It generally takes place when saturated, loose materials lose their strength and change into a fluid-like substance not capable of carrying significant loads. The tilting or sinking of structures is a likely result in such situations.

Zone II

Zone II consists largely of Merritt Sand. This area may experience a variety of types of ground failure due to ground motion particularly during the rainy season when the soil is saturated,

particularly if there is strong seismic activity. This area would probably be most susceptible to liquefaction.

Zone III

Zone III consists of older alluvial fan deposits. In many places this consists of weathered, weakly consolidated silt, sand, and gravel. The depth of these deposits may be up to several hundred feet thick near the bay margins. The generally deep cover of material over bedrock in this Zone may result in significant amplification of shaking during a shock.

Zone IV

Zone IV is composed of interfluvial basin deposits which are plastic, poorly sorted clays and silty clays in poorly drained areas. The thickness of this Zone is 10 feet or less and it may not experience any discernible amplification of shaking.

Zone V

Zone V contains the younger fluvial deposits which are unconsolidated deposits of fine sand, silt and silty clay. This deposit is generally less than 15 feet thick. There should be low amplification of shaking here but liquefaction is a possibility.

Zone VI

Zone VI are the younger alluvial fan deposits which consist of alluvial fill in narrow canyons and unconsolidated, moderately permeable fine sand and silt with gravel. The thickness of this Zone ranges from 20 to 50 feet. Amplification of the seismic wave will probably be moderate.

LANDSLIDES

Landsliding is a natural process of relatively rapid downslope movement of soil, rock, and rock debris as a mass. California's coastal mountain ranges are known for their abundance of landslides. One of the major contributing factors is the number of faults present in these ranges. Faults

are related to landslides in two ways. First, the steep mountain slopes associated with fault-laced ranges are ideal ramps for landslides. Second, the multiple fractures that occur within the fault zone shatter and weaken the rocks in such a way that they are more susceptible to landslides when they become overloaded with water. Of course, the likelihood of landslides is also modified by such factors as the actual slope angle, the mass and thickness of the soil deposits, the extent of vegetative cover and the extent slopes have been altered through grading.

Landsliding, as a natural hazard, can occur independently or as a result of seismic movement. Oakland has experienced landslides in recent years which generally have been triggered by the increased saturation and failure of soil rather than any seismic activity. Map 6 classifies Oakland into three general areas relating to their potential for landslide occurrences. The City maintains an extensive landslide file and specific sites or areas can be evaluated in more detail through its use.

TSUNAMIS

Tsunamis are large ocean waves, generated by rapid changes, usually in elevation of large masses of earth and water. They are commonly caused by vertical faulting beneath the ocean that rapidly moves a large volume of water toward an area that had been occupied by earth or away from any area that had been occupied by water. Such rapid movement sets up huge waves that can travel thousands of miles with destructive force. During the 1964 Alaskan earthquake, tsunamis crashed onto land areas more than 1,500 miles from the source area and devastated everything within their reach.

Tsunamis or seismic sea waves, often incorrectly referred to as tidal waves, have been recorded in San Francisco Bay for many years by the U.S. Coast and Geodetic Survey. The highest wave recorded during this period occurred in March 1964, the result of the Alaskan earthquake. This

wave reached a height of $7\frac{1}{2}$ feet at Fort Point. The amplitude or greatest elevation above or below the tide at that time was $3\frac{3}{4}$ feet (one half of $7\frac{1}{2}$). Tidal gauges throughout the bay indicate that the amplitude of tsunami waves vary from place to place.

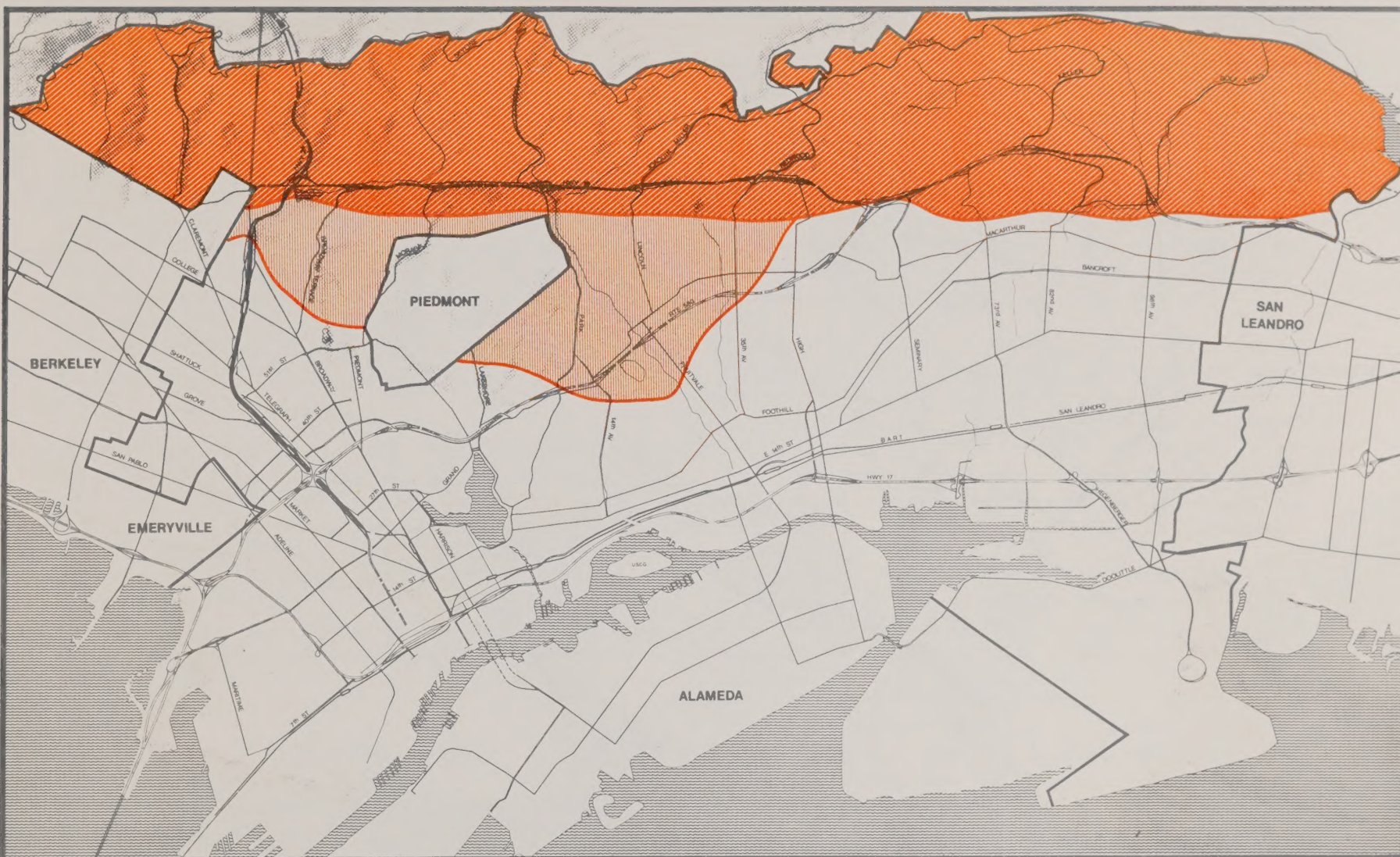
Map 7 shows the areas of the City of Oakland that may be affected by tsunamis. These areas are primarily the Oakland Army Base, U.S. Naval Supply Center, and a small areas of the Oakland Airport. The rest of the shoreline of the City of Oakland is "protected" by the City of Alameda.

In addition to tsunamis from distant sources, there is a possibility that local events could produce this phenomenon. However, large tsunamis appear to be the result of vertical displacement of the sea floor, and the movements expected from faulting in the Bay Area would be mainly in a horizontal direction. The records at the time of the 1906 earthquake showed the wave measured at Fort Point as $\frac{1}{2}$ foot or less. With the lack of any data to the contrary, it is assumed that waves generated from local events would not be expected to be any larger than those recorded from distant sources.

SEICHES

Seiches are earthquake-generated waves within enclosed or restricted bodies of water such as lakes and reservoirs. They might be likened to the sloshing of water in a bowl or bucket when it is shaken or jarred. The waves can be tens of feet high or more and have devastating effects on people and property within their reach. Dams and reservoirs can be overtopped and large volumes of water released to inundate or flood downstream development.

Similar but even more catastrophic inundation can result during earthquakes from a dam failure or from large masses of earth that might be broken loose and slide into a reservoir or bay. The potential flooding aspects of such events will be discussed later in this chapter.



 III Most Susceptible

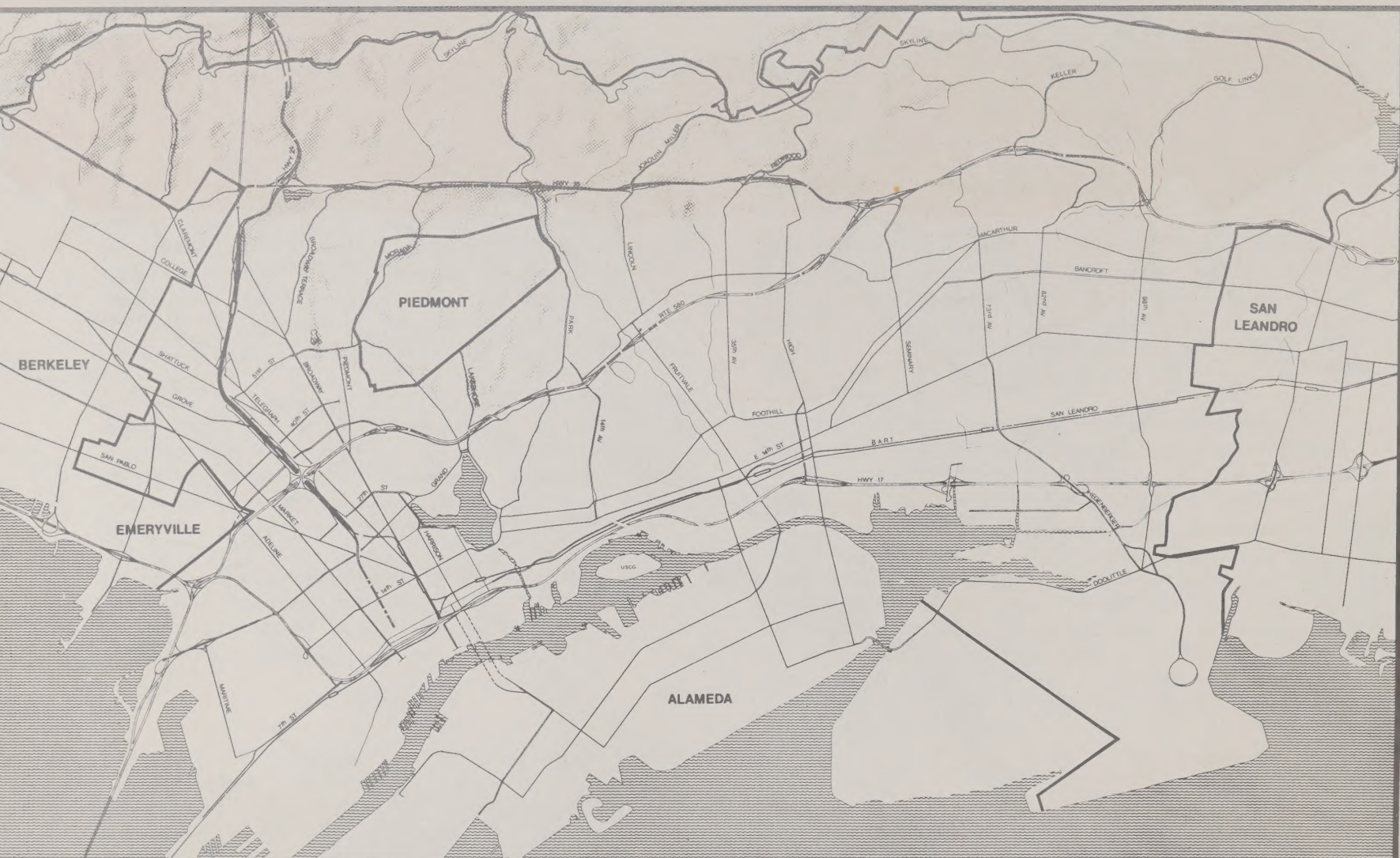
 II Moderately Susceptible

 I Least Susceptible

MAP 6 Relative Landslide Potential

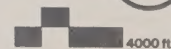


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MAP 7

Areas of Potential Inundation by Tsunamis



**OAKLAND
CITY PLANNING
DEPARTMENT**

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Fire Hazards

Vegetation in the Oakland hills ranges from densely wooded forests to open grasslands, and virtually all of the area is vulnerable to fire. The wooded areas present serious fire hazards because of the supply of fuel from trees and the possibility of crown fires which could quickly get out of control. The grass and brush areas are highly flammable but more easily controlled, unless these fires spread over to the wooded areas.

Map 8 delineates the City's critical fire areas as determined by Fire Department studies, reports from the Office of Parks and Recreation, and aerial photographs. Not shown, but particularly pertinent to Oakland's critical fire areas, is the East Bay Regional Park system which abuts the City of Oakland along the ridge of the hills. Thick vegetation in the wild lands of the parks adds to the fire dangers in Oakland.

Flood Hazards

A considerable amount of work has been done on mapping areas in Oakland subject to flooding. This data was collected as part of the federal government's flood insurance program. The program provides subsidies for flood and mudslide insurance, usually through insurance companies, but only in cities which meet certain minimum requirements of land use and building controls in areas likely to be flooded.

Delineation of flood hazard areas is shown on Map 9. This information is based on engineering studies performed in 1971 by an engineering consulting firm under contract to the U.S. Army Corps of Engineers. Modifications have been made to reflect work completed since then by the Alameda County Flood Control District. Based on the requirements of the National Insurance Program, the study shows areas subject to inundation during a "100-year flood."

As the term implies, a 100-year flood represents highly unusual flood conditions--estimated to have a one-percent chance of occurring each year. These flood levels have been computed from engineering and hydrologic studies, and projections have been made analytically to delineate areas where flood waters would extend above the tops of the street curbs. These levels were then extended, for mapping purposes, to the next identifiable feature, such as streets or railroads.

The map indicates extensive areas of inundation. In most of these areas, however, flooding would actually occur only as sheet flow with depths of several inches. Few locations would have flood depths exceeding one or two feet. Hence, the most serious dangers resulting from the 100-year flood levels would probably be potential damage to property, rather than any threat to life.

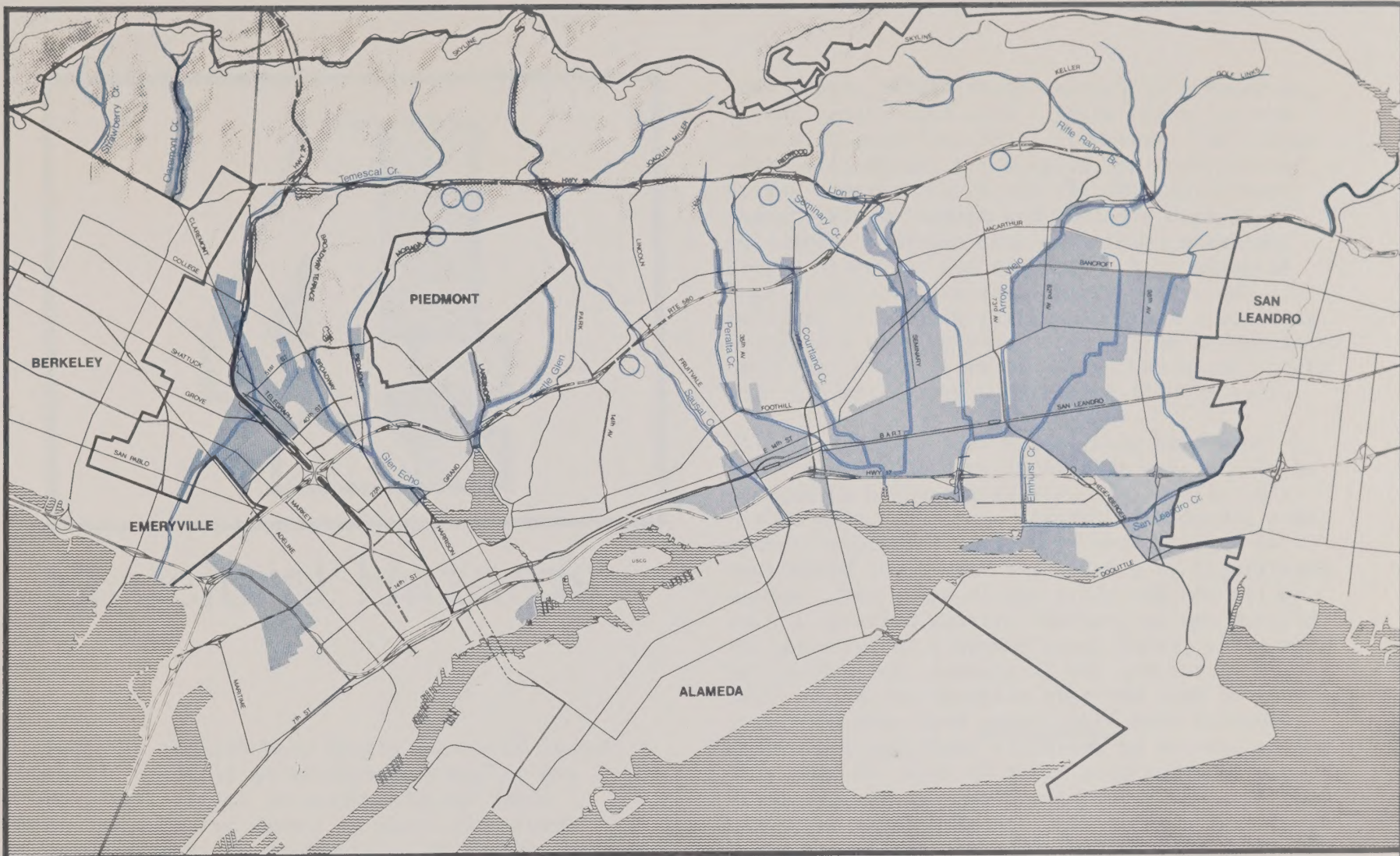
In addition to storm conditions, flooding could occur as a result of dam failure at one of the water reservoirs located in the City. The East Bay Municipal Utilities District has eight water reservoirs, some of which could cause significant flooding in the event of failure. The East Bay Regional Park District has one such facility, Lake Temescal. The location of these facilities is shown by Map 9. In the event of failure of one of these facilities, flood waters would normally follow existing stream beds or drainage courses. As required by recent State legislation, engineering studies have been undertaken by these two agencies to determine the extent of potential flooding from dam failure. Findings from these studies are now at the State Office of Emergency Services for review and copies are on file at each of these local agencies. State legislation (Section 8589.5, State Government Code) requires that the local Office of Emergency Services adopt emergency provisions for public safety measures to be taken in the event of such a disaster.



MAP 8
Critical Fire Areas



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MAP 9

Potential Flooding Areas

○ Reservoir

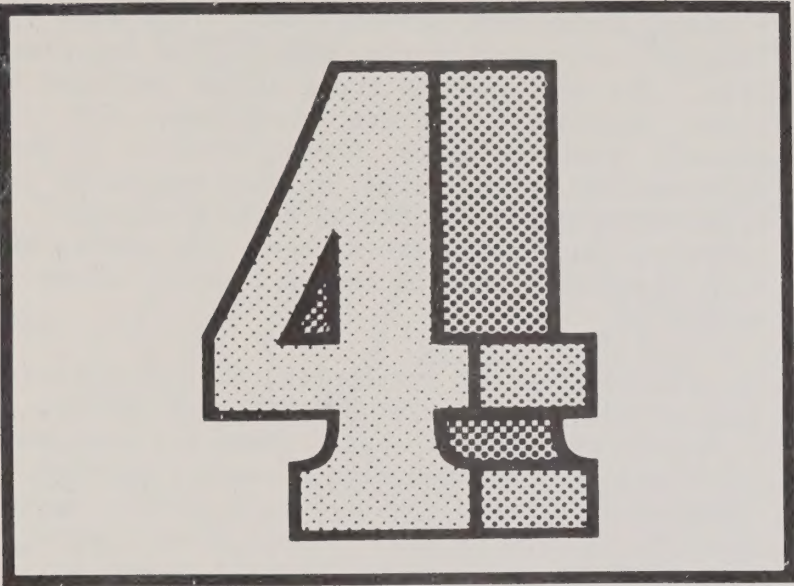


Flood Prone Areas



OAKLAND
CITY PLANNING
DEPARTMENT

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4

Structural Hazards

Possibly the greatest single source of hazard in the event of an earthquake would be the resultant effect on structures and their occupants. The manner in which structures respond to earth movements is dependent on the construction type, underlying geology and of course the intensity of the movement.

Seismic design standards for new construction were not included in building codes until the 1930's. Additionally, the evaluation and inspection of building plans and construction was not nearly as thorough as today. The seismic design standards in the Uniform Building Code are minimum standards and are not meant to represent the best possible manner in which to deal with seismic design.

Certain building types have responded well during seismic activity while others have consistently failed and have been the source of extensive damage and life loss. Most experts agree that a

wood-frame, single-story residential structure, if not constructed over a fault trace, is the most earthquake resistant structure. Buildings with unreinforced brick walls, or unreinforced hollow concrete block are the structures most susceptible to damage and collapse even in relatively moderate shocks. Although seismic design standards and techniques have advanced considerably in the last thirty years, no building is totally earthquake proof. Building design and construction today can be accomplished such that a structure can withstand major shocks with minimal damage and reduced life hazards.

This study deals with potentially hazardous structures as well as facilities which could be damaged by seismic activity. To develop definitive data concerning structural hazards, individual structures could have been studied to determine those most susceptible to significant damage. The scope of the study did not allow such a detailed survey. Rather, it was decided to identify, on a census tract basis, the number of residential, commercial and industrial structures whose construction type and year of construction made them potentially more hazardous than other buildings subjected to seismic action. This does not mean that all structures of a particular type or age would respond in the same manner to an earthquake nor does it mean that there would necessarily be massive damage in areas containing higher concentrations of such buildings. The potential response of any one building to an earthquake can only be determined by a thorough analysis of that specific structure by an expert after sufficient site testing.

Residential Structures

The study focused on residential structures of three units or larger. It was assumed that one and two unit structures, which are primarily wood-frame, would be most likely to resist damage.

Census data on the number of three-plus-unit structures constructed prior to 1939 was used, since information concerning the construction

type for residential buildings was not available. The data analyzes the concentrations of such units in Oakland, and estimates the number of buildings which fall into this category. Map 10 indicates the percent of all housing units in each census tract which are in structures of three-plus-units. As can be seen, the greatest concentration of multiple family units is in Oakland's central area and in the vicinity of Lake Merritt. Map 11 shows the estimated total number of such residential buildings constructed prior to 1939. Comparing these two maps reveals certain census tracts which have high concentrations of multi-family residential units in buildings which may be more susceptible to damage in case of earth movements.

Two-and three-story apartment buildings are least likely to experience severe damage, given wood-frame construction, a moderate earthquake and stable geologic conditions. Damage to such structures would probably include failure of fireplaces, chimneys, and ornamental veneer. Larger apartment buildings of varying construction types built prior to 1939 did not need to meet any seismic design standards. Therefore, it would be necessary to inspect each building to ascertain how it might resist earthquakes.

Generally, it can be said that significant concentrations of buildings of twenty-plus units are to be found in the central area thus earmarking this area as one needing special attention both as to building evaluation and policy formation concerning the degree of hazard this may represent. Beyond the central area, there are only minor concentrations of large multiple-family units, the majority of which have been constructed after 1940. Within the designated Special Seismic Studies Zone there are no major groupings of such structures.

Commercial and Industrial Structures

To study commercial and industrial buildings, County Assessor's data* on file in the City

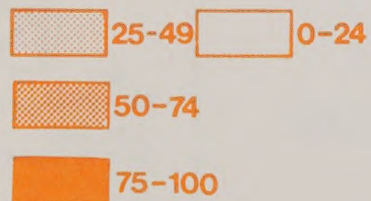
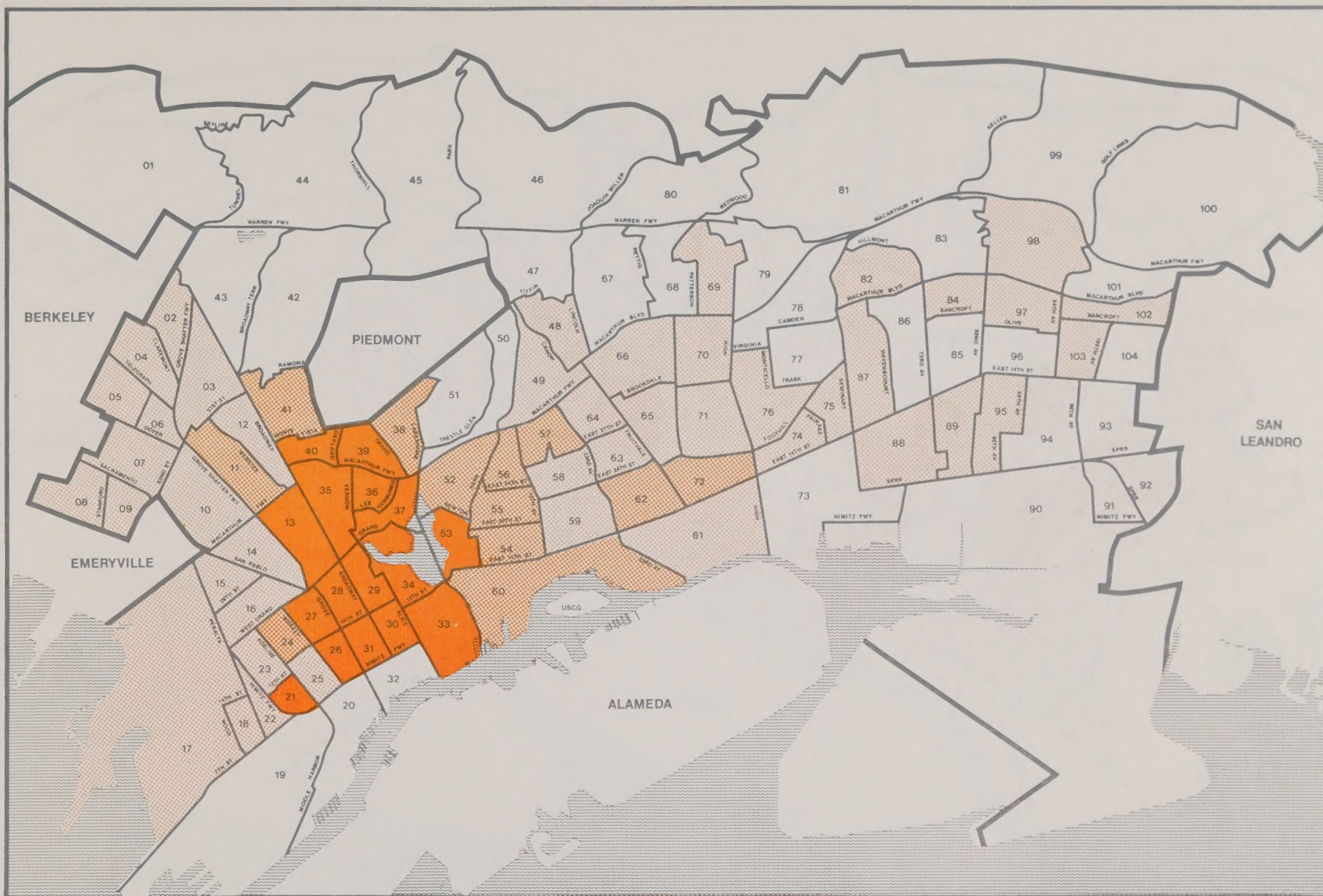
Planning Department was utilized. This data included construction type and year of construction. The construction types listed included steel, reinforced concrete, wood-frame, and masonry (concrete block, stone, brick). Of the construction types listed, masonry buildings constructed prior to 1940 have the greatest potential for earthquake damage. The number of such structures in each census tract is shown on Map 12.

As with residential structures, the concentration of older commercial buildings is primarily within the central area. There are also some concentrations along Oakland's major thoroughfares such as East 14th Street, San Pablo Avenue, Foothill Boulevard, etc. Census tracts below East 14th Street from Lake Merritt to approximately Seminary Avenue also have a significant number of such structures, most of which are in industrial uses.

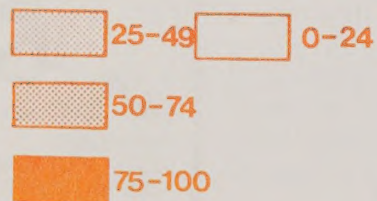
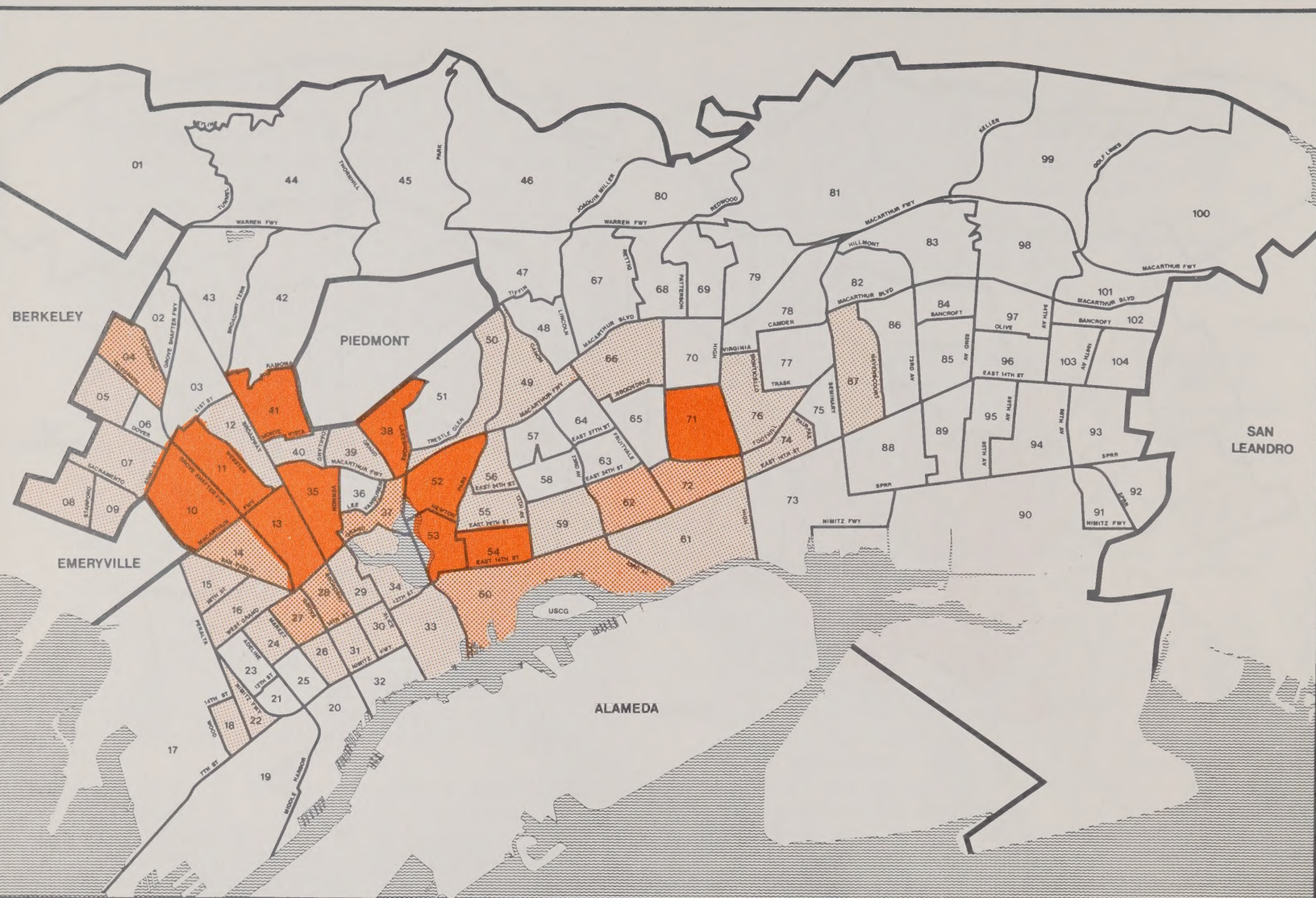
The most significant hazards presented by such structures are the potential failure of unreinforced walls, particularly unreinforced brick parapets. Additionally, some such structures have clay tile roofs. The tiles, if not securely fastened, can break and fall during earth movements. Tilt-up wall construction utilized in industrial structures is a relatively new construction technique. This may well present a problem in the event of an earthquake. Advertising signs and other ornamentation on commercial buildings can also be hazardous if their anchorages are not secured to structural elements.

Industrial structures can present even more hazards to occupants due to the mechanical equipment which might be affected by earthquakes, as well as possible toxic or flammable materials utilized in the manufacturing process. As with

*Data collected for Comprehensive Development Plan project in 1968.



MAP 10
Percent of Housing Units
in Structures of 3+ Units



MAP 11
**Estimated Number of Residential
 Buildings With 3 or More Units
 Built Before 1939**



MAP 12
**Number of Commercial and Industrial
 Masonry Buildings Constructed Before 1940**



- Hospitals
- Fire Stations
- ◆ Schools

MAP 13
**Location of Hospitals, Fire Stations,
 and Public Schools**



residential buildings, comprehensive inspections would be required to clearly ascertain which commercial and industrial buildings in Oakland would be most susceptible to damage.

Public and Semi-Public Structures

Certain types of public and semi-public structures must be considered in evaluating structural hazards because of the functions they serve and because of the possible loss of life which might result from their future.

SCHOOLS

Public schools in California have been given special legislative attention concerning earthquake safety since the 1933 Long Beach earthquake. As a direct result of the damage done to schools by this earthquake, the California Legislature passed a bill, known as the Field Act, which made a high degree of earthquake bracing mandatory for all new school structures. Existing schools, private schools and the University of California were excluded from this law. Current provisions of the California State Education Code further specify that all school buildings not meeting the Field Act safety standards may not be used for classroom purposes after June 30, 1975.

Oakland has responded to the need to replace its pre-Field Act schools by the passage of a multi-million dollar bond issue which will replace 29 schools with new structures. The replacement of these facilities is necessary for the protection of students, and in addition, such facilities can become disaster centers in a major catastrophe.

The location of school facilities in Oakland can be seen on Map 13. There are eight schools within the designated special earthquake studies zone, all of which have been constructed in conformance with earthquake standards.

HOSPITALS

There are ten major civilian hospitals and one

military hospital in Oakland. The major health facilities in the City have undergone periodic renovations, additions and rebuilding. Therefore, the construction type and specific configurations of such structures vary greatly. In each instance the California Department of Public Health Bureau of Planning and Construction oversees the design standards utilized in hospital construction. Earthquake design considerations are incorporated in such construction. As can be seen on Map 13 there are no civilian hospitals located within the special earthquake studies zone in Oakland.

The Oak Knoll Naval Hospital complex which contains approximately 650 beds is the only major medical facility in Oakland which is located adjacent to the Hayward fault. The newest structures in the complex have been designed to earthquake standards, however, experts feel that ground rupturing may reasonably be expected within the this complex in the event of a significant movement on the fault.

How any of these facilities would be able to resist significant damage can only be ascertained by a thorough investigation of each facility. Non-structural damage such as the movement of equipment, furniture and fixtures, can be expected. Additionally, in the case of Oak Knoll, accessibility to the facility may be seriously curtailed due to possible damage to freeway ramps and access roads which closely parallel the fault in that area.

FIRE STATIONS

The majority of Oakland's fire stations have been designed to be earthquake resistive or are of inherently earthquake resistive wood-frame construction. Five of the stations were built prior to 1930. The location of each station is shown on Map 13.

Three of the five pre-1930 stations are located in the Hayward fault zone. In the event of a significant shock these three facilities may be rendered inoperable. The necessity of all stations to

function following a destructive earthquake is evident given the need to suppress fires resulting from such a disaster. In addition to the immediate problems of structural damage to facilities, there may also be access problems in fire response due to the collapse of bridges, and ramps, damaged utility lines (water, gas, sewer) and general rubble and debris.

OTHER PUBLIC STRUCTURES

There are a variety of other City-owned facilities in Oakland including the City Hall, Police Administration Building, Oakland Auditorium and libraries, which could incur structural damage in the event of a major earthquake. The City Hall, constructed in 1914, has a steel frame. Although total failure of the building is unlikely, significant non-structural damage to exterior ornamental features and interior facilities might be sustained. An investigation of the Oakland Auditorium for the City by a structural engineer in 1966 revealed that the building has suffered damage due to the differential settlement of the entire structure. This was attributed to the fact that the original piles for the building did not sufficiently penetrate into firm ground below the bay mud. The engineer further concluded that there was little hazard to life due to collapse of the structure in the event of an earthquake, since it had a steel frame. In the event of an earthquake equal to the one in 1906, however, the Auditorium would suffer serious damage making it virtually unusable.

Many library buildings are of pre-1940 vintage. To ascertain their earthquake resistiveness would require individual inspections.

Definitive information concerning other public structures is not readily available.

Utility and Transportation Facilities

Utility systems generally are designed and

operated to allow the systems to remain in a functioning condition after a disaster. In that the forces and effects caused by earthquakes are still not fully understood, geologic hazards can only be minimized at best. Utilities must cross earthquake faults in many cases, and sometimes they must be located in structurally poor ground areas such as landslide-prone regions.

The Pacific Gas and Electric Company as well as other utilities design their installations to much more rigid standards than required by building codes. In some instances, such as with the East Bay Municipal Utility District facilities, they are developed on both sides of the fault to avoid disruption due to earth shocks. The need for such stringent standards is evident when considering the fact that Oakland's water, natural gas and some electrical facilities cross the Hayward fault. (Detailed locational maps of these facilities are on file at each utility company.) In the event of a major earthquake, disruption in utility service to some extent can be expected.

In addition to the necessary utility lines which cross the fault in Oakland, there is also a major petroleum distribution line. The line is not in operation presently due to a slide which damaged portions of it. Studies have been undertaken on the possible re-routing and the re-design of the line. Earthquake hazards have been considered in the redesign including an elaborate system of automatic cutoff valves which would stop petroleum flow in case of a shock or rupture of the line. The geologic and geographic situation of Oakland is such that utilities are forced to cross the fault area, but in each instance the responsible companies attempt to develop their facilities so that they may continue to function in the event of a disaster.

The principal problems which might beset the City's transportation network include earth failure due to landslide or subsidence, damage to freeway overpasses and ramps and damage to the Bay Bridge. Major landslides or movements are

distinctly possible with heavy ground motion which might leave stretches of Oakland's freeway impassable. Hydraulic fills used to construct miles of freeways along the Bay's shore may liquefy and fail under heavy shaking.

The structural integrity of the many overpasses and similar structures in Oakland also must be considered. The 1971 San Fernando earthquake resulted in the failure of freeway interchanges and overpass structures most of which were under construction. The design details and lateral force design standards utilized on those structures were reviewed and significantly modified to prevent such damage in the future. The performance of these structures in the San Fernando area may indicate that freeway structures in Oakland are equally susceptible to damage from a major earthquake. Any failure in the elevated interchange structures would also effect the accessibility and usability of the Bay Bridge. Additionally, the earth fills underlying the approaches to the Bay Bridge from Oakland may be subject to extensive slippage and differential settlements due to strong ground motion.

Portions of the MacArthur Freeway and all of the Warren Freeway are within the special earthquake study zone and portions are constructed over potentially active faults. In the event of a major shock it may be expected that damage to these freeways could be extensive, resulting in isolation of the areas east of them. Local streets in the same area may be subjected to landsliding or ground rupture, further limiting access.

Seismic hazards to the BART system were taken into account in its design and major efforts were taken to reduce hazards. All of BART's elevated track in East Oakland is supported by precast, prestressed concrete beams in turn supported by poured-in-place steel reinforced concrete columns on adequate foundations. Some of BART's elevated track goes through structurally poor ground and it may be reasonable to expect some damage to the system in the event of a

major earthquake.

Oakland's Port facilities and airport are situated on structurally poor ground. Much of this ground is fill over bay mud or marshland. Such ground can be subjected to heavy shaking during a major earthquake. It is reasonable to assume that there may be some damage to these facilities given a significant earthquake.



Areas of Hazards and Risks

Hazard Prone Areas

The previous two chapters have identified various types of hazards and contain maps of their general location within Oakland. This chapter correlates the most significant identified hazards with more specific areas of the City. The areas identified as being potentially hazardous on Map 14 are general in nature. Specific sites within these areas may not contain these specific hazards. As an outgrowth of the composite mapping of hazards, five distinct areas have emerged: the Oakland Hills, East Oakland, Central Oakland, West Oakland and the Shoreline.

OAKLAND HILLS

This area, generally east of the Warren Freeway, is less densely developed than most of the City. The development pattern consists of single-family homes with a scattering of commercial clusters. The area may be subject to a combina-

tion of hazards. The Hayward fault generally parallels the Warren Freeway. The fault creates a hazard from possible earth displacement, both vertical and horizontal, to structures within the Special Studies Zone. In addition to potential ground shaking, which would be felt throughout the City, structures within this area on or directly adjacent to the Hayward fault could be damaged or destroyed by the actual physical shifting along the fault line or the deformation of adjacent land. Besides the shifts which could occur during an earthquake, the area immediately adjacent to the fault line is subject to tectonic creep. Although this creep is less than one inch a year, structures can be significantly affected over a period of years.

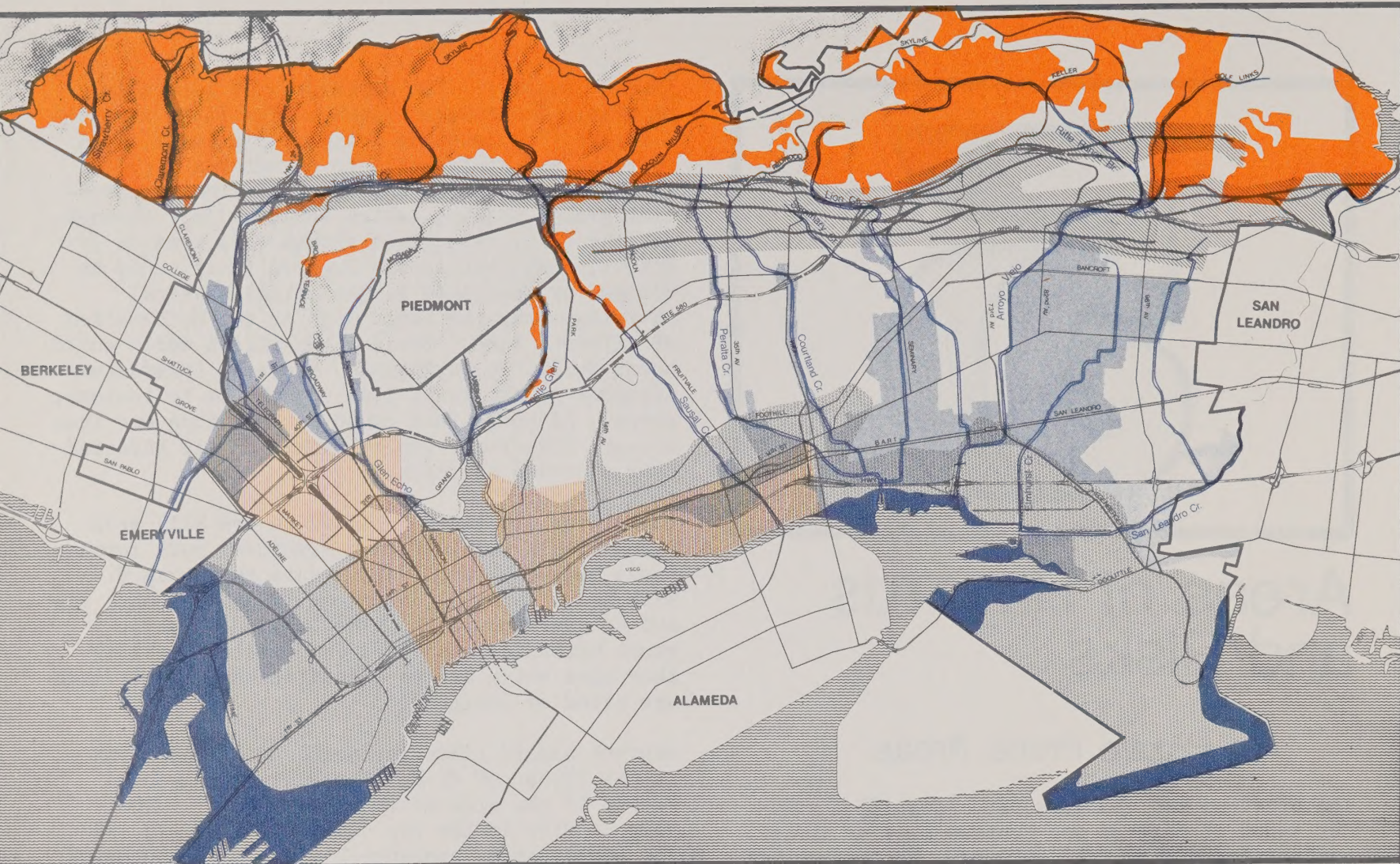
Landslides are another hazard in the hill area. Steep slopes combined with fractured rock formations caused by faulting, create this hazard. With heavy rainfall, numerous landslides have resulted over the years. The Office of Public Works maintains landslide information covering this area which may be consulted before buildings are sited or designed.

Another hazard affecting portions of this area is the threat of fire. The grassy and wooded nature of the area makes it especially vulnerable to fire in the dry summer months. In 1973, the added danger presented by the dead and dried eucalyptus trees caused the City and other effected agencies to take steps to reduce the immediate danger caused by those trees. The City has also gone on to prepare for the possibility of a major fire, as well as other possible disasters.

EAST OAKLAND

This area is generally between MacArthur Boulevard and East 14th Street east of Lake Merritt. The area is developed in residential uses with commercial concentrations along major arterials. The residential development is primarily low-medium density with some clusters of high density.

With the exception of seismic action, only one hazard to portions of this area exists--flooding.



-  Critical Fire Areas
-  Structural Hazards
-  Special Studies Zone
-  Poor Ground Response
-  Flood Prone Areas
-  Tsunami Hazards

MAP 14
Hazard Prone Areas



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Flooding in this area would occur only under highly unusual conditions, if ever (see Chapter 3). If such flooding did occur, it would be at a depth of only a few inches and would not present a direct threat to life or cause significant damage to structures.

Earthquake hazards here are less than within other areas of the City. The majority of structures are single-family wood-frame. The underlying soils are such that ground shaking should not be unduly amplified. Of course the intensity of an earthquake could be such that even the most resistant structures might fail.

WEST OAKLAND

This area, generally west of the Grove-Shafter Freeway extension and below the MacArthur Freeway, has a mixed land use pattern. It contains low to high density residential developments as well as commercial and industrial concentrations.

The area may be susceptible to earthquake damage since portions are underlain with soil types which have, in other locations, tended to fail under intense shaking. The specific hazards associated with these soil types have been discussed in Chapter 3. These soils have the potential for causing damage to structures which would normally be resistive to earthquakes, and they intensify the potential hazards to buildings which have not been designed to earthquake standards. Concentrations of structures which are hazardous due to their age and type of construction compound this hazard.

Parts of West Oakland which protrude into the Bay are also subject to tsunami damage. This of course might only occur in a significant local, off-shore earthquake, with much less possibility of such an occurrence from a distant earthquake elsewhere in the Pacific region.

CENTRAL OAKLAND

This area--primarily the downtown section west of Lake Merritt--is Oakland's most densely de-

veloped residential commercial area. It also has the most significant concentration of hazardous structures in the City due to their age and type of construction. In a major earthquake, many older buildings here may be hazardous to life. Parapets and other ornamentation which are not properly secured to structural members may fall in the event of a severe earthquake, endangering pedestrians. In addition, some buildings have poor structural integrity which may lead to extensive damage in even a moderate earthquake. Unfortunately, these defects cannot be easily identified and may be even more difficult to remedy.

The soil types underlying most of this area intensify the problems, as they tend to respond poorly to severe ground shaking. The area directly surrounding Lake Merritt, for example, was once marshland.

In a very intense earthquake, the Central area may experience extensive structural damage and possible loss of life. The latter is directly related to the density of development and intensity of activity. Oakland's Central area, of course, is not unique. In earthquake prone cities the central area is usually the oldest portion of the City and has the greatest concentration of buildings and people: consequently, one may conclude that during a major earthquake the central area may well be the most hazardous area of any city. The reconstruction of portions of Oakland's downtown through redevelopment and private development is eliminating a number of structurally deficient buildings. Although new high-rise buildings incorporate stringent earthquake standards, the response of structures to a severe earthquake can only be theorized.

SHORELINE

This area lies to the east of Lake Merritt and generally below San Leandro Street. It fronts on the Estuary, San Leandro Bay or San Francisco Bay. Industrial uses dominate although there are a few clusters of residential development. Hazards which affect this area relate to soils, structures and tsunamis, as well as the more gen-

eral earthquake hazard.

The predominant soil profile in this area consists of fill material over bay mud or marshland. This soil type has been associated with intensified earthquake damage. Hazards relating to this soil type include ground cracking, ground lurching, and differential settlement (see Chapter 3).

Hazardous structures identified in this area are concentrated below East 14th Street west of High Street. The major portion of such structures is in commercial or industrial use. While the area is not densely developed, these buildings could be hazardous to their occupants. In addition to structures hazardous due to age and type of construction, are structures designed to resist earthquakes, but which may experience damage because of intensified ground movement. In other areas with similar soil conditions, structures have withstood earthquakes, but have tilted or settled due to ground failure. There is, then, a likelihood of property damage in this area in a major earthquake. The type of construction employed in some industrial buildings combined with the intensification of movement due to soil conditions could result in extensive damage and possible life loss. Public transportation facilities including the freeway, BART and the airport could all be subject to damage as a result of intensified movement or ground failure. The design of most new facilities in this area reflects the consideration for this potential hazard; however, the actual performance of new structures has not been tested by a major earth movement.

Although much less of a hazard, portions of this area are susceptible to tsunami danger as discussed in Chapter 3. The areas adjacent to San Leandro Bay and portions of Oakland Airport could be affected by such occurrences.

Planning For Emergencies

The Oakland City Council adopted an Emergency

Operations Plan on September 27, 1973, (Resolution No. 53550). It prescribes the conduct and coordination of operations in the event of a disaster. The Plan has been prepared to respond to various kinds of possible emergencies, including natural disasters, major transportation or industrial accidents, epidemics, and war. The objectives of the Plan are to:

1. Provide for the continuity of government.
2. Provide a basis for direction and control of emergency operations.
3. Save lives and protect property.
4. Repair and restore essential systems and services.
5. Provide for the protection, use, and distribution of remaining resources.
6. Coordinate operations with the Emergency Services organizations of other jurisdictions.

The Emergency Operations Plan is a comprehensive framework for the coordination of emergency operations. The plan establishes the authority, responsibilities, functions, and operations of civil government during emergencies. It also provides for bringing in non-governmental agencies and organizations having resources necessary to meet emergency requirements. The plan ties in with the State of California Emergency Plan, which provides a statewide system for coordinating city, county, regional, and state emergency operations.

In Oakland the Office of Emergency Services (OES), a division of the Police Department, is responsible for developing and maintaining the Emergency Operations Plan. The OES is in the process of refining the City's Emergency Operations Plan to provide the following components:

1. Fire Suppression Plan.
2. Earthquake Disaster Plan.

3. Industrial Disaster Plan.
4. Transportation Disaster Plan.
5. Flood Disaster Plan.
6. Tsunami Disaster Plan.

These various reports will establish more detailed procedures for responding to each type of disaster. The OES is expecting to complete all of the above plans by early 1975.

Acceptable Risk

The City's Emergency Operations Plan has been developed to respond to all major hazards which might endanger life or property. In developing and maintaining this plan, the City is attempting to minimize loss of life and property in the event of a disaster.

While maintaining this capacity to respond in the face of a disaster, the City is also developing preventative measures to minimize hazards prior to a disaster. The City has attempted to incorporate such measures in development controls when hazards are known to be present. For example, the City's Building Code demonstrates a concern for earthquake resistant construction standards, and the Fire Code requires special development standards in critical fire areas. How far the City can go in attempting to eliminate hazards before the costs, both economic and social, become greater than the probable effects of the disaster is an unanswered question. It is at such a point that the City reaches the level of "Acceptable Risk." Acceptable risk is a concept pertaining to the level of risk below which no specific action by local government is deemed necessary.

This report may be viewed as a starting point in developing a framework for determining acceptable risk. The study identifies hazards, discusses potential consequences, and serves as an information document for all residents and

property owners in the City to become better aware of environmental dangers. Wider knowledge throughout the community of these hazards will enable residents to assist City officials in determining Acceptable Risk levels.



Policies and Programs

General Considerations

The previous three chapters have served to identify, locate, and discuss a variety of hazards in Oakland. These hazards include those that occur naturally as well as those that occur as a result of man's modification of the natural environment. One may conclude that these hazards do represent potential risks to both life and property. How the City of Oakland should deal with these risks is discussed in this chapter.

At least two broad alternative courses of action are open to the City:

1. it could accept the presence of such hazards and make no special effort to mitigate their effects; or
2. it could follow a course of action aimed at preventing the creation of new risks and the eventual elimination of existing ones.

Should the City choose the second alternative, then the degree of City participation must be

determined. The elimination and prevention of risks due to natural hazards represents certain costs both direct (as exemplified by inspection and abatement costs) and indirect (the possible loss of economic benefits associated with the prohibition of development in certain areas).

The recommended goals are:

To minimize the loss of life, injuries, and damage to property, of Oakland citizens resulting from natural disasters.

To recognize natural environmental hazards in planning for the City's future development.

These goals take into consideration both the need to reduce risks and hazards and the necessity to allow appropriate development.

POLICY

At some point, the allocation of community resources for the prevention of a given hazard may outweigh the potential losses that might be incurred if such an event were to occur. As discussed in Chapter 5, the balance point between expenditures and potential losses might be termed the level of acceptable risk. Determining this level of risk calls for more time and consideration by a broader cross-section of the community than is possible at this time, and hence the following policy is suggested:

1. *Establish programs and take appropriate actions to insure a reasonable level of safety from geologic, seismic and fire hazards within Oakland, based upon due consideration of individual property rights and consistent with investment of community resources in preventative programs.*

PROGRAM

The following program is an important first step in developing programs which involve significant amounts of community resources, public and private:

The City Council should develop a framework for determining levels of acceptable risk for geologic, seismic and fire hazards within the City of Oakland.

The recommendations in this chapter provide a policy framework within which to deal with more specific hazards and a series of companion programs to effectuate the policies.

Geologic Hazards

Geologic hazards, as discussed here, are meant to include those hazards which are not necessarily or directly related to seismic activity --such as landsliding and unstable soils. Oakland has, in the past, dealt with such hazards through its building permit procedure. The Building Department requires soils reports and engineered foundations in areas of identified hazards. The Office of Public Works administers a grading ordinance which regulates the movement of earth related to land development. Grading in hazardous areas as well as grading plans which could cause future problems are subject to review. This office is also responsible for preventive maintenance in known hazard areas and has developed maps and data on identified landslides and other earth movement in Oakland. This file can be useful as a starting point for pinpointing specific problem areas. The City's subdivision and Planned Unit Development (PUD) regulations are administered by the City Planning Department. The Subdivision Regulations require soils reports as a routine matter unless waived. Although not specifically required by the PUD regulations, soils reports are often submitted. The recently instituted environmental impact procedures also have provisions for such analyses. All of these provisions are aimed at determining, prior to development, if there are any potential geologic hazards. There are no provisions for investigating sites with existing facilities developed in areas with suspected hazards.

POLICIES

Although regulations and procedures for dealing with most geologic hazards in areas to be developed already exist, specific policies to establish a framework for the continuation and possible expansion of these programs are set forth below:

A number of policies already adopted by the City pertain directly to Seismic Safety and Safety and have been incorporated into the element. Other existing policies have been modified to this end. The majority of the following policies, however, have been developed specifically to deal with there hazards in Oakland.

1. *Except where adequate corrective measures can feasibly be taken, construction should not occur over known faults or on land subject to landslide, erosion, or flooding. The City will continue to make efforts to obtain more information about such hazardous areas, and will consider the imposition of additional controls on development there.*
2. *The City should maintain an ongoing program to monitor and refine data on both geologic and seismic hazards.*
3. *Development involving significant alteration of natural land forms or surface conditions should generally be discouraged on slopes greater than 30 percent.*

PROGRAMS

Although the City's existing procedures for determining potential hazards, especially in conjunction with new development, is quite comprehensive, the following three general program areas are intended to further strengthen the City's involvement in this area:

1. The City should more effectively disseminate information on areas of known geologic hazards.

The Office of Public Works has files and knowledge of such hazard areas that allows them to provide at least preliminary information concerning identified geologic hazards. Such information can be useful as a first step in pinpointing specific problems which may affect both existing and future property owners in Oakland.

2. The City should also intensify its efforts to regularly gather and refine new information dealing with geologic hazards. State and Federal data sources should be utilized to the maximum extent possible.
3. The City should continue and, if necessary, expand its preventive maintenance of drainage facilities. Monitoring of landslide and other areas susceptible to earth movement should continue, and additional measures should be instituted as required.

There is little that the City can do to directly eliminate geologic hazards; however, through the maintenance and dissemination of information, adequate maintenance of drainage facilities, and the proper regulation of development it can minimize potential hazards to property and lives.

Seismic Hazards

Unlike certain geologic hazards such as landslides, which may occur from time to time in some areas, major seismic activities are so infrequent that they do not generate a sustained public concern; however, a major tremor such as the 1971 San Fernando earthquake quickly reminds people of the potential hazards associated with seismic activity. In the past, the City's most direct involvement with seismic activity was generally limited to ensuring that building plans conformed to the earthquake standards in the building code. In addition, there has been a requirement for soils reports in areas of new land development to identify potentially unstable building sites; however, the responsibility for accommodating any identified hazards rested with the developer. The primary responsibility for ensuring that buildings

are of earthquake resistant design actually rests with the architects and structural engineers involved with a given building.

This rather minimal involvement with seismic hazards has begun to intensify substantially, however. The major development leading to this change has been the Alquist-Priolo Geologic Hazard Zones Act adopted by the State Legislature in 1972. The Act provides for the identification and mapping of all known active faults in California by the State Geologist and the subsequent mapping of a Special Studies Zone which generally encompasses an area bounded by lines one-eighth of a mile on either side of identified potentially active faults. Within the zone, special restrictions are imposed on development. The most important of these include:

1. the prohibition of construction of all structures for human occupancy across the trace of an active fault;
2. within 50 feet of the fault it must be proven that there are no active traces of the fault; and
3. all other proposed developments within the Special Studies Zone must submit geologic reports prior to the issuance of building permits or approval of subdivisions.

This legislation, coupled with the requirement for a Seismic Safety Element, has generated a new concern for seismic hazards at the local governmental level throughout most of the State. Some communities in California have experienced extensive earthquake damage in the past and have consequently developed local codes and ordinances over the years to deal with this hazard; however, this is the first time major state-wide efforts have been undertaken affecting such a broad scale of development. Oakland has prepared an ordinance to implement this law at the local level.

This law deals primarily with new construction in a specific area. There is a need to expand this concern with seismic safety to both new and existing structures on a city-wide basis since a severe

enough earthquake could affect almost any portion of Oakland. Therefore, the City's concerns should extend to all new construction, existing structures which may be potentially hazardous and an overall land use policy which consistently recognizes seismic hazards as a factor in the City's development processes.

POLICIES

The policies set forth below cover a wide range of seismic related concerns and are intended to form the framework for implementation actions and programs relating to seismic hazards.

1. *The City in conjunction with other governmental agencies should embark on a program of disseminating available seismic safety information to citizens and property owners.*
2. *The City in conjunction with other governmental agencies, when feasible, should utilize lands subject to severe seismic and geologic hazards for low intensity park and recreational activities or open space.*
3. *The City and other public agencies should not locate public facilities for human occupancy in fault zone areas unless all other available sites are infeasible. If such facilities must be located in a fault zone, geologic studies should be undertaken to determine the suitability of the site.*
4. *The City should consider prohibiting critical facilities such as hospitals, schools, utility installations and communication centers from locating on lands subject to severe seismic or geologic hazards.*
5. *The City will employ the most current seismic design criteria in the construction of new public buildings. Buildings to accommodate activities and equipment related to public safety, especially police, fire and communication services, should be constructed to ensure continued operation and availability of service after an earthquake.*

6. *The City should consider establishing a program to have structures highly susceptible to seismic damage either reinforced or demolished. Priority for abatement action should be based on the type of occupancy and the severity of risk.*

PROGRAMS

Programs to effectuate suggested policies vary in both scope and timing. Some programs can be instituted rather quickly and without significant economic impact upon the City. Others must be long term, depending on objectives. The priority and specifics of suggested programs are obtained below:

1. The City with the assistance from other governmental agencies should develop and disseminate seismic safety information to Oakland citizens. This should include such matters as :
 - a. what to do in case of an earthquake;
 - b. how to get official information in case of a disaster;
 - c. directions to the closest disaster center;
 - d. public health information.

The aim of such program would be to inform citizens of hazardous conditions and let them know their government can act in an emergency. Disaster plans prepared by the City and other agencies should be publicized as part of the information program. The ability to administer regulations concerning seismic hazards as well as to evaluate them and propose new ones is dependent on detailed information. It isn't necessary for the City itself to develop such data as long as it is in a position to obtain new data regardless of its source. Such data is needed now.

2. Structural hazards which might result from a severe earthquake within Oakland are also a prime concern. A long-term program to identify and abate such hazards should be considered.

- This would be a costly program both to the City and affected property owners. Such a program would include provisions for the inspection of all hazardous buildings including structural members, exterior ornamentation and signs all of which could be hazardous in an earthquake. Structures in need of reinforcement or modification should be required to have the work done or be closed to human occupancy and have exterior hazards removed. Clearly such a program in Oakland would be a major undertaking; however, it would be necessary if the City were to reduce potential hazards to the minimum possible. As part of such an inspection process the City should evaluate all public buildings to determine their ability to withstand seismic forces.
3. The City's existing codes and ordinances regulating development should be reviewed and modified if necessary to ensure their consistency with seismic policies. When more refined seismic data are available relating to soils response, it would appear possible, as well as highly desirable, to overhaul the City's Building Code to require specific seismic loadings by soils zones. As seismic data is refined, it may also be possible to modify the Zoning Regulations to more closely relate land use activities to the degree of seismic hazard.
 4. The City's ordinance implementing the Alquist-Priolo Act focuses on the development of land and new structures within the prescribed study zone. The City should consider additional regulations covering the construction or placement of other facilities which could be affected by seismic activity. Streets, utilities, transmission lines and pipelines are all facilities which may need to traverse seismic hazard areas, and some degree of local regulation may be needed. The capability of the City to develop specific criteria for such facilities is limited presently, but as appropriate criteria are developed, they should be applied.
 5. The State's expanding concern for seismic safety may produce additional legislation in the area of abatement. This could provide the necessary legal foundation for local laws.
 6. The City should also urge State and Federal agencies to develop new programs to aid local governments in dealing effectively with existing buildings and facilities that might present a hazard to life or property in the event of a severe earthquake.
 7. In addition, the City urges State and Federal agencies to continue research aimed at refining earthquake data and developing workable building code provisions based on seismic monitoring and construction technology and testing.

Fire Hazards

An effective fire fighting capability exists today in Oakland. However, the best way to deal with fire is to prevent its occurrence. While this is not possible in many cases, it is possible to create conditions which minimize fire hazards and facilitate efficient response.

Oakland has worked on a long term continuous basis to minimize fire hazards by developing appropriate codes and ordinances relating to land development. The Building and Housing Department administers the fire safety provisions in the Uniform Building Code. The Fire Department administers a fire prevention program on a city-wide basis. Fire safety measures are exercised in all areas of public assembly and in the handling of dangerous material.

Most of the City's fire prevention measures have been directed toward the developed areas and especially the central area of the City where large concentrations of older, multi-storied buildings are located. These areas have the most at stake in terms of lives and property. The results of these measures have been a reduction in potential

losses.

Because of the 1972 freeze of eucalyptus trees in the Oakland hills, a concerted effort has been directed toward reducing the critical fire hazards in this area. The Fire Department, the Office of Parks and Recreation, and the Office of Public Works have been working with other agencies to reduce fire hazards in the hills. Continued work is still needed to: create effective fuel breaks between urban and non-urban areas; maintain good horticulture practices throughout the hill area, and revegetate the hills where necessary with native plants resistant to fire and freezing.

Fuel breaks are an important part of the strategy for fire control as they can slow a fire and provide an entrance for fire fighting personnel. Fuel breaks are especially critical for the separation of wild undeveloped land from developed areas. Along fuel breaks, vegetation should include low-growing ground covers having a low volume of fuel and low heat production, but for appearance, planned so as not be noticeable or to appear as an artificial cut through the hillsides.

Vegetative management is another important part of the City's fire and erosion control strategy. Where necessary the hills should be replanted with native materials resistant to fires, separating grass from flammable brush and trees to maintain a separation or discontinuity of fuels. Discontinuity of fuels can be achieved through good horticultural practices, including the use of fire resistant ground cover, clearance of underbrush or ground fuel, pruning of trees to prevent contact with surrounding fuel, and the judicious use of chemicals for vegetation control.

Control of fuel on private properties is equally important. In the 1970 fire, houses were saved where people had cleared around their homes. Where brush and debris were thick around homes, they were lost. The main way of reducing these fire hazards is by clearing debris, dead vegetation, overhanging limbs of trees and removing

high hazard fuel plants, such as acacia, from residential properties.

POLICIES

The following two policies form the framework for implementation actions and programs relating to fire hazards; they are all new:

1. *Continue the Fire Department's fire prevention program, including the inspection of existing buildings and the review of proposed development to ensure maximum safety from potential fire hazards.*
2. *Develop programs to continue the reduction of fire hazards in the City's hill areas through vegetative management, incorporating considerations for the appearance of the hills as an integral part of these programs.*

PROGRAMS

The City's programs for fire prevention in urban areas are among the best in the country; the proposed programs which follow are intended to further strengthen the City's ability to prevent fires in the City's less urbanized areas:

1. Create and maintain effective fuel breaks between urban and non-urban areas, vegetating the fuel breaks with low-growing ground covers having a low volume of fuel and low heat production.
2. The Office of Parks and Recreation and the Fire Department should develop appropriate programs for vegetative management for public properties and develop educational programs for residents and property owners in the area to inform them of the necessity for vegetative management on private property.

Flooding Hazards

Flooding in Oakland is not considered a hazard to

life because flood depths calculated for the 100-year flood would reach, for the most part, only a few inches and would result mostly in sheet flow. However, a few locations in the City would experience depths of several feet, but even in these cases the hazards would be in terms of property damage rather than losses of life.

The Alameda County Flood Control and Water Conservation District is responsible for the construction, maintenance and operation of the major storm drainage facilities along the City's creeks and tributaries, and the Office of Public Works is responsible for the storm drainage system leading to the major creeks and channels.

The Flood Control District is undertaking flood control and drainage improvement projects on the basis of priority needs. The most significant flood control problems will be resolved throughout the City by 1978. In the design of its projects, the Flood Control District should balance the objectives of protecting property against the consideration of environmental and recreational open space needs.

FLOOD INSURANCE

Congress has passed a national flood insurance program which provides federal subsidies for flood insurance to protect property owners in flood-prone areas. In return, the City is required to adopt certain land use controls to reduce or avoid future flood damage in flood-prone areas. If a property owner within an area designated as floodable during the 100-year flood fails to buy the required insurance, or if the City fails to comply with the land use regulatory requirements, federal or federally-related financial assistance (including most mortgage loans) will be unavailable to that property. As an example of insurance costs, \$87.50 per year would be charged for a \$35,000 home.

DEVELOPMENT CONTROLS

The City's Subdivision Regulations have provisions which protect against possible flood

damage. Flood plain zoning for the extensive areas designated as floodable in the 100-year flood is not considered appropriate because these areas are already developed. Rather than a flood plain zone, the Building Code should be used to protect new construction or major rebuilding against flood damage in the future. All new construction or any major improvements to existing structures should be built at a level equal to or higher than the 100-year flood elevation. This regulation could be administered by the Building and Housing Department as part of building permit procedures. The developer or property owner would be responsible for demonstrating that the elevation of the proposed development would be above the 100-year flood. Federal flood insurance should not be mandatory for structures built above the 100-year flood level.

Appeals should be made to the Federal Insurance Administration to waive any unnecessary requirements for structures in Oakland built above the 100-year flood elevation. Otherwise, as the Administration's guidelines are now written, unnecessary hardships could be placed on present and future homeowners in Oakland.

MUDSLIDES

There are large areas of soil instability throughout Oakland which could result in mudslides during conditions of flooding and ground saturation. In areas of known soil instability, the City's Office of Public Works should continue to assign priority for street maintenance crews to guard against blockages in the storm drainage system, preventing, wherever possible, ponding on and surface run-off over areas of potential mudslides.

VEGETATIVE MAINTENANCE

The planting of appropriate ground cover and other vegetation can assist in stabilizing soils and possibly prevent certain types of landslides. The City should develop programs to encourage extensive planting in areas of soil instability

and in areas of new development where grading has removed the top soil and native vegetation. The plant materials should be a low maintenance variety which is fire resistant.

POLICIES

The following are new policies which formally recognize actions and positions already taken by the City with respect to flooding and drainage:

- 1. *The City fully supports the Alameda Flood Control and Water Conservation District's program for eliminating flood hazards in the City of Oakland, endorsing the District's policy of balancing the costs of new projects against the potential damage that might result from flooding.*
- 2. *The City will insist upon flood control designs which preserve trees and the natural character of the creeks to the maximum extent possible.*
- 3. *The City will participate in the Federal Insurance Program to enable property owners who desire and/or need flood insurance to acquire it at reasonable rates.*

PROGRAMS

The following programs should be initiated or continued to further implement the policies dealing with flood hazards:

- 1. The Building and Housing Department and the Office of Public Works should together develop a program for determining the acceptable elevations for new construction or major improvements to existing structures located in areas defined by the Federal Insurance Administration as being within the 100-year flood plain.
- 2. The City should formulate the appropriate development controls to participate in the

Federal Insurance Program and appeal to the Federal Insurance Administration for a waiver of any requirements not applicable to Oakland if their application places an unnecessary hardship on property owners.

- 3. To reduce the danger of mudslides or landslides during the rainy season, the Office of Public Works should continue to assign high priority to having its street maintenance crews guard against blockages in the drainage system which might lead to ponding on or surface run-off areas known to have unstable soils.
- 4. To reduce the problems of excessive run-off, erosion, and landslides, the City should, in addition to requiring adequate drainage facilities, insure that appropriate vegetation is planted and maintained on sloping areas, areas known to have unstable soils, and areas which have been left bare by new development.

Safety During Emergencies

The preceding pages have dealt primarily with the formulation of policies and programs which are preventative in nature, which attempt to reduce existing hazards. Of course, no community can develop a completely hazard free environment. Thus, the City of Oakland has developed an Emergency Operations Plan which describes the authority and responsibilities for responding to emergencies during a natural or man-made disaster.

The Emergency Operations Plan is a comprehensive plan of action to be taken in the event of a major disaster. The plan is maintained by the Office of Emergency Operation in the Police Department, which is now refining the plan to develop special courses of action for specific types of emergency.

The City should continue to update the Emergency Operations Plan and ensure that all agencies and departments affected are aware of their respective

roles in the event it becomes necessary to implement the plan.

POLICY

The following new policy formally recognizes action already taken by the City in the area of emergency planning and confirms the City's intention of maintaining the plan on a continuous basis:

1. *The City Council assigns high priority to the maintenance and continual updating of the Emergency Operations Plan to insure that the City will be able to respond effectively in the face of disaster.*

PROGRAMS

The following programs are intended to encourage continued improvement of the work already begun and ensure the dissemination of relevant information to all participants:

1. The Office of Emergency Operations should continually update the Emergency Operations Plan and require that all departments and agencies involved in emergency operations maintain a current knowledge of their responsibilities.
2. The Office of Emergency Operations should periodically stage a practice drill on a specific type of emergency situation to familiarize participants with their responsibilities.

Appendix 1

MODIFIED MERCALLI SCALE OF EARTHQUAKE INTENSITIES (AS MODIFIED BY CHARLES F. RICHTER IN 1956 AND REARRANGED)

<u>If most of these effects are observed</u>	<u>then the intensity is:</u>
Earthquake shaking not felt, but people may observe marginal effects of large distance earthquakes without identifying these effects as earthquake-caused. Among them: trees, structures, liquids, bodies of water sway slowly, or doors swing slowly.	I
<u>Effect on people:</u> Shaking felt by those at rest, especially if they are indoors, and by those on upper floors.	II
<u>Effect on people:</u> Felt by most people indoors. Some can estimate duration of shaking, but many may not recognize shaking of building as caused by an earthquake; the shaking is like that caused by the passing of light trucks.	III
<u>Other effects:</u> Hanging objects swing. <u>Structural effects:</u> Windows or doors rattle. Wooden walls and frames creak.	IV
<u>Effect on people:</u> Felt by everyone indoors. Many estimate duration of shaking. But they still may not recognize it as caused by an earthquake. The shaking is like that caused by the passing of heavy trucks, though sometimes, instead, people may feel the sensation of a jolt, as if a heavy ball had struck the walls. <u>Other Effects:</u> Hanging objects swing. Standing autos rock. Crockery clashes, dishes rattle or glasses clink. <u>Structural effects:</u> Doors close, open or swing. Windows rattle.	V
<u>Effect on people:</u> Felt by everyone indoors and by most people outdoors. Many now estimate not only the duration of shaking but also its direction and have no doubt as to	

If most of these effects are observed

then the intensity is:

its cause. Sleepers wakened.

Other effects: Hanging objects swing. Shutters or pictures move. Pendulum clocks stop, start or change rate. Standing autos rock. Crockery clashes, dishes rattle or glasses clink. Liquids disturbed, some spilled. Small unstable objects displaced or upset.

Structural effects: Weak plaster and Masonry D* crack. Windows break. Doors close, open or swing.

VI

Effect of people: Felt by everyone. Many are frightened and run outdoors. People walk unsteadily.

Other effects: Small church or school bells ring. Pictures thrown off walls, knickknacks and books off shelves. Dishes or glasses broken. Furniture moved or overturned. Trees, bushes shaken visibly, or heard to rustle.

Structural effects: Masonry D* damaged; some cracks in Masonry C*. Weak chimneys break at roof line. Plaster, loose bricks, stones, tiles, cornices, unbraced parapets and architectural ornaments fall. Concrete irrigation ditches damaged.

VII

Effect on people: Difficult to stand. Shaking noticed by auto drivers.

Other effects: Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Furniture broken. Hanging objects quiver.

Structural effects: Masonry D* heavily damaged; Masonry C* damaged, partially collapses in some cases; some damage to Masonry B*; none to Masonry A*. Stucco and some masonry walls fall. Chimneys, factory stacks, monuments, towers, elevated tanks twist or fall. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off.

VIII

*Masonry A: Good workmanship and mortar, reinforced designed to resist lateral forces.

Masonry B: Good workmanship and mortar, reinforced.

Masonry C: Good workmanship and mortar, unreinforced.

Masonry D: Poor workmanship and mortar and weak materials, like adobe.

If most of these effects are observed

then the intensity is:

Effect on people: General fright. People thrown to ground.

Other effects: Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes. Steering of autos affected. Branches broken from trees.

Structural effects: Masonry D* destroyed; Masonry C* heavily damaged, sometimes with complete collapse; Masonry B* is seriously damaged. General damage to foundations. Frame structures, if not bolted, shifted off foundations. Frames racked. Reservoirs seriously damaged. Underground pipes broken.

IX

Effect on people: General panic.

Other effects: Conspicuous cracks in ground. In areas of soft ground, sand is ejected through holes and piles up into a small crater, and, in muddy areas, water fountains are formed.

Structural effects: Most masonry and frame structures destroyed along with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes and embankments. Railroads bent slightly.

X

Effect on people: General panic.

Other effects: Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land.

Structural effects: General destruction of buildings. Underground pipelines completely out of service. Railroads bent greatly.

XI

Effect on people: General panic.

Other effects: Same as for intensity X.

Structural effects: Damage nearly total, the ultimate catastrophe.

Other effects: Large rock masses displaced. Lines of sight and level distorted. Objects thrown into air.

XII

Appendix 2

GLOSSARY

<u>Active faults.</u>	Faults which show evidence of any or all of the following: 1. Topographic or physiographic expressions suggestive of geologically young fault movements. 2. Fault creep. 3. Records of surface rupture within or adjacent to the study area in historic time.
<u>Aggregate.</u>	Materials such as sand, gravel, and crushed rock, with which cement or bituminous material is mixed to make concrete or asphalt.
<u>Alluvial fans.</u>	Alluvial fans are built by rivers flowing from mountains onto lowlands. They are low cone-shaped heaps, steepest near the mouth of the valley, and sloping gently outward with ever decreasing slope.
<u>Alluvium.</u>	A general term for the sediments laid down in river beds, flood plains, lakes, fans at the foot of the mountain slopes, and estuaries during relatively recent geologic times.
<u>Amplification.</u>	The increase in earthquake ground motion that may occur to the principal components of seismic waves as they enter and pass through different earth materials.
<u>Bedrock.</u>	Any solid rock underlying soil, sand, clay, etc.
<u>Colluvium.</u>	Soil deposited by soil creep, landslides and surface wash.
<u>Compaction.</u>	Decrease in volume of sediments, as a result of compression of sediments deposited above them.
<u>Conglomerate.</u>	A rock composed of larger fragments (such as pebbles or cobbles) set in a matrix of finer material (such as sand, silt, and/or clay).
<u>Consolidated material.</u>	Soft or hard rock which requires some medium of loosening at the excavation site before it can be handled. The more loosening required (i.e., blasting as opposed to bulldozing) the more consolidated the material.
<u>Damping.</u>	A resistance to vibration that causes a progressive reduction of motion with time or distance.

<u>Differential settlement.</u>	Loss of strength or the loss of water and sand through liquefaction often does not occur evenly over broad areas. Thus the ground settles different amounts in adjacent spots. Can be very destructive to buildings.
<u>Displacement.</u>	The dislocation of one side of a fault relative to the other side resulting from fault movement.
<u>Earth-flow.</u>	A slow flow of earth lubricated with water. Earth-flows may be discriminated from earth-slumps by reason of their greater mobility.
<u>Earthquake.</u>	Perceptible trembling to violent shaking of the ground, produced by sudden displacement of rocks below and at the earth's surface.
<u>Epicenter.</u>	The geographical location of the point on the surface of the earth that is vertically above the earthquake focus.
<u>Fault.</u>	An earth fracture or zone of fracture along which the rocks on one side have been displaced in relation to those of the other.
<u>Fault block.</u>	A body of rock bounded by one or more faults.
<u>Fault creep.</u>	Very slow periodic or episodic movement along a fault trace unaccompanied by quakes.
<u>Fault slip or slippage.</u>	The relative displacement of formerly adjacent points on opposite sides of a fault. Also known as fault creep.
<u>Fault system.</u>	Two or more fault sets formed at the same time.
<u>Fault surface.</u>	The surface along which dislocation has taken place.
<u>Fault trace.</u>	The intersection of a fault and the earth's surface as revealed by dislocation of fences, roads, by ridges and furrows in the ground, etc.
<u>Fault zone.</u>	A fault instead of being a single clean fracture, may be a zone hundreds or thousands of feet wide; the fault zone consists of numerous interlacing small faults or a confused zone of gouge, breccia or other material.
<u>Faulting.</u>	The movement which produces relative displacement of adjacent rock masses along a fracture.
<u>Formation.</u>	A rock body or an assemblage of rocks which have some character in common; applied to a particular sequence of rocks formed during one epoch; a rock unit used in mapping.
<u>Frequency.</u>	The number of seismic wave peaks which pass through a point in the ground in a unit time. Usually measured in cycles per second.
<u>Geology.</u>	The science which deals with the earth, the rocks of which it is composed, and the changes which it has undergone or is undergoing.

<u>Ground cracking.</u>	Cracks usually occurring in stiff surface materials resulting from differential ground movement.
<u>Ground failure.</u>	A situation in which the ground does not hold together such as in landsliding, mud flows, liquefaction and the like.
<u>Ground lurching.</u>	Undulating waves in soft saturated ground that may or may not remain after the earthquake.
<u>Ground strength.</u>	The limiting stress that ground can withstand without failure by rupturing or by rupturing or continuous flow.
<u>Ground response.</u>	The reaction of the ground to earthquake shaking.
<u>Hayward fault.</u>	A large and active branch of the San Andreas Fault System. It has been the center of many earthquakes, including the 1868 earthquake which was one of the largest ever to hit Northern California.
<u>Inactive faults.</u>	Identifiable faults which do not meet any of the criteria listed under "active faults."
<u>Intensity.</u>	A nonlinear measure of earthquake size at a particular place as determined by its effect on persons, structures, and earth materials. The principal scale used in the United States today is the Modified Mercalli, 1956 version. Intensity is a measure of effects as contrasted with magnitude which is a measure of energy. They are not the same.
<u>Inundation.</u>	Flooding caused by water topping a dam or water released by dam, reservoir, levy or other break.
<u>Landsliding.</u>	The perceptible downwardsliding or falling of a relatively dry mass of earth, rock or mixture of the two. Often loosely used to also include sliding of wet earth masses such as mudslides and earthflows.
<u>Liquefaction.</u>	A process by which a water saturated sand lens loses coherence when shaken. Involved is the collapse of sand grains into intergranular voids which induces an increase in pore pressure and loss of strength. This loss of strength leads to a quicksand condition in which objects can either sink or float depending on their density.
<u>Magnitude.</u>	The rating of a given earthquake is defined as the logarithm of the maximum amplitude on a seismogram written by an instrument of specified standard type at a distance of 62 miles from the epicenter. It is a measure of the energy released in an earthquake. The zero of the scale is fixed arbitrarily to fit the smallest recorded earthquakes. The scale is open ended but the largest known earthquake magnitudes are near 8-3/4. Because the scale is logarithmic, every upward step of one magnitude unit means a 32 fold increase in energy release. Thus, a magnitude 7 earthquake releases 32 times

as much energy as a magnitude 6 earthquake. Magnitude is not the same as intensity.

Mudflow or
mudslide

A flowage of heterogeneous debris lubricated with a large amount of water.

Normal fault.

Vertical movement along a sloping fault surface in which the block above the fault has moved downward relative to the block below.

Scarp.

An escarpment, cliff, or steep slope of some extent along the margin of a plateau, terrace, bench, and at the top of a slide.

Sediment.

Solid material settled from suspension in a liquid.

Sedimentary
rocks.

Rocks, commonly stratified, formed by the accumulation of sedimentation in water or from air.

Seiche.

Earthquake generated waves within enclosed or restricted bodies of water (lakes, bays, reservoirs, etc.).

Seismograph.

An instrument that writes a permanent continuous record of earth vibrations.

Seismic.

Pertaining to an earthquake or earth vibration, including those that are artificially induced.

Subsidence.

A shrinking of a large area of land, usually observed as a shrinkage.

Tectonic.

Pertaining to or designating the rock structure and external forms resulting from the deformation of the earth's crust. Pressures causing such deformations often result in earthquakes.

Tsunami.

A sea wave produced by large areal displacements of the ocean bottom, often the result of earthquakes or volcanic activity. Also known as seismic sea waves.

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Map of "Late Cenozoic Deposits Alameda County" and GQ769 - Source for report Map 5.

"Estimated Relative Abundance of Landslides in the San Francisco Bay Region, California" - Source for report Map 6.

Map MF 480 (1972) - Source for report Map 7.

O A K L A N D C I T Y C O U N C I L

Resolution No. 54240 C.M.S.

RESOLUTION ADOPTING FIRES, FLOODS, AND GEOLOGIC
HAZARDS - THE SEISMIC SAFETY AND SAFETY ELEMENT
OF THE OAKLAND COMPREHENSIVE PLAN.

WHEREAS, the City Planning Commission has held a public hearing on consideration of adopting the Seismic Safety and Safety Element and establishing a seismic safety and safety section of the Oakland Policy Plan, thereby adding to and amending the Oakland Comprehensive Plan and Oakland's "general plan"; and

WHEREAS, the City Planning Commission has approved the document entitled Fires, Floods and Geologic Hazards-The Seismic Safety and Safety Element and has recommended that said document be adopted by the City Council; and

WHEREAS, subsequently the City Council has itself held a public hearing on these matters; and

WHEREAS, pursuant to the provisions of the California Environmental Quality Act of 1970, as amended, and City Council Resolution No. 53054 C.M.S. (adopting objectives, criteria, and procedures for implementation of said Act) the City Planning Commission has approved an Environmental Impact Report on the proposed Seismic Safety and Safety Element, and the City Council has subsequently reviewed and considered said Environmental Impact Report; now, therefore be it

RESOLVED: That the Council of the City of Oakland finds that said Seismic Safety and Safety Element may have a significant impact upon the environment, and certifies that the aforesaid Environmental Impact Report, a copy of which is on file with the City Clerk, has been prepared in compliance with the California Environmental Quality Act of 1970, as amended, and State guidelines; and be it

FURTHER RESOLVED: That the City Council finds and determines that the Seismic Safety and Safety Element provides an appropriate and systematic statement of City goals, policies, and intentions regarding seismic safety and safety; and be it

FURTHER RESOLVED: That the City Council hereby adopts the document, Fires, Floods, and Geologic Hazards-The Seismic Safety and Safety Element, a copy of which is on file with the City Clerk and is available there for inspection by the public; and be it

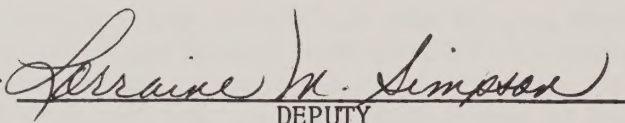
FURTHER RESOLVED: That the Seismic Safety and Safety Element hereinabove adopted is hereby declared to be a component of the Oakland Comprehensive Plan as well as Oakland's "general plan"; and be it

FURTHER RESOLVED: That the Oakland Policy Plan is hereby amended by establishing a seismic safety and safety section by adding the appropriate goal and policy statements contained in the Seismic Safety and Safety Element, hereinabove adopted, to said section, and by adding or substituting said goal and policy statements to other sections, as appropriate.

I certify that the foregoing is a full, true and correct copy of a Resolution passed by the City Council of the City of Oakland, Calif., on September 10, 1974.

ROBERT C. JACOBSEN
CITY CLERK

Per


DEPUTY



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